E-ISSN: 2746-7767
Ainara Journal (Jurnal Penelitian dan PKM Bidang Ilmu Pendidikan)
Volume 7, Issue 3, September 2026, pp 527-536
https://doi.org/10.54371/ainj.v7i3.1461

The Effect of The SAVIR Model on Sixth-Grade Students' Mathematical Communication Skill and Learning Motivation in Solid Geometry Concepts

Zefanya Melinda Cahyaningrum[1], *Dani Kusuma[2]
[1,2]Elementary School Teacher Education Study Program, Faculty of Teacher Training and Education, Universitas Kristen Satya Wacana, Salatiga, Indonesia
Correspondence Email: dani.kusuma@uksw.edu

Article History: Submission: 2026-05-13 || Accepted: 2026-09-01 || Published: 2026-09-20

Abstract

This study examined the effect of the SAVIR learning model, consisting of Case Study, Artificial Intelligence, Augmented Reality Visualization, Interaction, and Reflection, on sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. A quantitative quasi-experimental pretest-posttest control group design was employed involving 43 sixth-grade students at SDN Kutowinangun 08 Salatiga, comprising 22 students in the experimental class and 21 students in the control class. The experimental class received instruction using the SAVIR model, whereas the control class was taught using Problem Based Learning (PBL). Data were collected using a mathematical communication test and a learning motivation questionnaire and analyzed using t-tests, a binomial proportion test, and simple linear regression. The two groups demonstrated comparable initial mathematical communication skills, with pretest means of 60.38 for the experimental class and 60.42 for the control class ($p = 0.932$). After the intervention, the experimental class obtained a mean posttest score of 81.09, compared with 72.28 in the control class, and the difference was statistically significant ($p = 0.003$). Furthermore, 90.9% of students in the experimental class achieved the minimum mastery criterion. Regression analysis indicated an R^2 of 0.433 for mathematical communication skills ($p < 0.001$) and an R^2 of 0.202 for learning motivation ($p = 0.036$). These findings indicate that SAVIR was associated with higher mathematical communication performance and learning motivation in three-dimensional geometry learning. Nevertheless, further studies involving larger samples and multiple schools are needed to confirm the effectiveness and generalizability of the model.

Keywords: *SAVIR Model, Mathematical Communication Skills, Learning Motivation, Concepts, Three-Dimensional Geometry.*

I. INTRODUCTION

Mathematics education at the elementary school level plays an important role in developing students' logical and analytical thinking, problem-solving, and communication skills required to meet the demands of the 21st century. Within the Kurikulum Merdeka (Independent Curriculum), mathematics learning is directed not merely toward procedural mastery but also toward developing students' reasoning and mathematical communication through deep and student-centered learning experiences (Ardian et al., 2024). These competencies are particularly important in three-dimensional geometry, where students are required to construct representations of three-dimensional objects and understand the relationships among their constituent elements. Geometry inherently requires visual representation to support the development of a more concrete understanding of three-dimensional concepts (Eviota & Liangco, 2020). Therefore, geometry instruction should extend beyond recognizing shapes and applying formulas by providing opportunities for students to visualize, explain, and communicate mathematical ideas logically and systematically.

Despite its importance, geometry learning at the elementary school level continues to present considerable challenges. The PISA 2018 report showed that Indonesian students obtained an average mathematics score of 379, indicating a continuing need to strengthen their ability to use mathematical knowledge to understand and solve problems across different contexts (OECD, 2019). In geometry learning, these challenges may manifest as difficulties in developing spatial representations and distinguishing the elements of three-dimensional shapes, such as faces, edges, and vertices. Rizki et al. (2025) explained that the abstract nature of geometric concepts requires concrete visual support to enable students to develop appropriate spatial representations. These difficulties may become more pronounced when instruction remains dominated by teacher explanations and formula memorization, thereby limiting opportunities for students to construct and communicate their mathematical understanding (Royani & L, 2020).

Similar conditions were identified through preliminary observations at SDN Kutowinangun 08 Salatiga. Students experienced difficulties in distinguishing the elements of three-dimensional shapes, tended to participate passively in classroom discussions, and rarely explained the reasoning processes they used when solving problems. In addition, some students demonstrated low learning motivation because they perceived geometry as difficult and confusing. These preliminary findings indicate that the instructional challenges involve not only students' understanding of geometric concepts but also limited opportunities to communicate mathematical ideas and participate actively in the learning process. Such conditions highlight the need for an instructional design that integrates visual experiences, problem solving, interaction, and learning support to foster both mathematical communication and student motivation.

From a pedagogical perspective, effective geometry instruction should provide concrete, interactive, and meaningful learning experiences that enable students to develop a deeper understanding of three-dimensional objects. Santoso (2022) emphasized the importance of integrating visualization, object manipulation, and mathematical communication into geometry learning so that students not only understand the forms and properties of three-dimensional shapes but can also explain their reasoning systematically. Mathematical communication plays an important role in enabling students to organize, interpret, and communicate mathematical ideas logically (Aulia & Surya, 2023). This perspective is also consistent with deep learning-oriented instruction, which provides opportunities for students to actively explore concepts, collaborate, engage in discussion, and reflect on their learning experiences (Cahya et al., 2023). Geometry instruction therefore requires a design that connects conceptual visualization with intellectual and social activities through which students can observe, manipulate, discuss, and reflect on the concepts being learned.

Previous studies have demonstrated the potential of technology and interactive approaches to support geometry learning. Saputra et al. (2022) reported that the use of Augmented Reality (AR) in three-dimensional geometry improved students' spatial representation skills by up to 21% while supporting their ability to explain geometric concepts orally and in writing. Agus Purnomo (2022) similarly reported that AR-based interactive media could enhance students' learning motivation by providing more concrete and challenging visual experiences. Meanwhile, Tauhid (2025) found that the use of Artificial Intelligence (AI)-based modules significantly improved students' mathematical understanding through adaptive feedback tailored to individual learning needs. Collectively, these findings demonstrate the potential of AR and AI to support the visual, cognitive, and motivational dimensions of mathematics learning.

However, the presence of technology does not automatically lead to improved learning outcomes. Tari & Hutapea (2020), for example, found that the use of AR did not produce significant improvement when students were unfamiliar with digital devices or when adequate teacher guidance was unavailable. This finding suggests that the effectiveness of educational technology depends not merely on the availability of devices or applications but on how technology is embedded within a pedagogical design that structures student activities, scaffolding, interaction, and reflection. Therefore, the central issue is not simply whether AI or AR is incorporated into instruction, but how their respective functions are systematically integrated with problem-solving activities and mathematical communication.

Previous studies informing the present research have generally examined AR, AI, problem-based learning, or interactive learning as relatively independent approaches. Consequently, limited evidence is available regarding how problem contexts, AI-supported scaffolding, AR visualization, student interaction, and reflection can be organized within a single systematic instructional sequence, particularly to simultaneously develop mathematical communication skills and learning motivation in three-dimensional geometry. The research gap, therefore, lies not merely in the limited use of AI or AR in mathematics education, but in the limited examination of instructional designs that integrate the pedagogical functions of these components into a coherent learning sequence.

To address this gap, the present study implements the SAVIR model, which comprises five sequential learning stages: Study of Case, Artificial Intelligence, Visualization with Augmented Reality, Interaction, and Reflection. SAVIR is positioned as an integrative instructional design that organizes these five components according to their respective pedagogical functions. The Study of Case stage introduces a contextual problem as the starting point for activating students' reasoning; the Artificial Intelligence stage provides support for information exploration and problem solving; the Visualization with Augmented Reality stage assists students in constructing visual representations of three-dimensional objects; the Interaction stage provides opportunities for students to discuss, justify, and communicate mathematical ideas; and the Reflection stage guides students in reviewing the concepts, strategies, and reasoning processes employed throughout learning. Accordingly, the novelty of SAVIR lies not simply in combining AI and AR, but in organizing contextual problems–AI-supported scaffolding–AR visualization–interaction–reflection into a structured pedagogical sequence.

Based on this research gap, the present study aims to analyze the effect of the SAVIR model on sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. Specifically, the study compares the mathematical communication skills of students learning through SAVIR with those taught through Problem-Based Learning, examines the achievement of mathematical communication mastery following the implementation of SAVIR, and analyzes the relationship between SAVIR implementation and students' mathematical communication skills and learning motivation.

II. METHOD

This study employed a quantitative approach using a quasi-experimental pretest–posttest control group design. The study was conducted at SD Negeri Kutowinangun 08 Salatiga and involved 43 sixth-grade students. The sample consisted of 22 students from Class VI A assigned as the experimental group and 21 students from Class VI B assigned as the control group. The sample was selected using cluster sampling. The experimental group received instruction using the SAVIR model, whereas the control group was taught using Problem-Based Learning (PBL). Both groups completed a pretest before the instructional intervention and a posttest after the learning activities had been completed to identify changes in students' abilities and compare outcomes between the two groups.

The SAVIR model was implemented through five sequential learning stages: Study of Case, Artificial Intelligence, Visualization with Augmented Reality, Interaction, and Reflection. During the Study of Case stage, students analyzed contextual problems related to three-dimensional geometry as a basis for developing conceptual understanding and identifying problems. In the Artificial Intelligence stage, AI was used to support students' information exploration and understanding during problem solving. The Visualization with Augmented Reality stage utilized AR to assist students in visualizing and understanding representations of three-dimensional geometric objects. During the Interaction stage, students engaged in discussions, explained their reasoning processes, and communicated mathematical ideas. Finally, in the Reflection stage, students reviewed their understanding, strategies, and problem-solving processes throughout the learning activities.

Table 1. Experimental Research Design

No.	Group	Initial Condition	Treatment	Final Condition
1	Experimental (VI A)	T1 (*Pretest*)	SAVIR Model	T3 (*Posttest*)
2	Control (VI B)	T2 (*Pretest*)	PBL Model	T4 (*Posttest*)

The research instruments consisted of an essay test of mathematical communication skills and a learning motivation questionnaire. The test was used to assess students' abilities to explain mathematical ideas, use representations, and communicate mathematical problem-solving processes, whereas the questionnaire was used to measure students' learning motivation. The instruments were evaluated for validity, reliability, item difficulty, and discriminating power. The validity analysis showed that all 10 test items were valid, with the calculated r values exceeding the critical r value of 0.514. Reliability testing yielded a Cronbach's Alpha coefficient of 0.920, indicating very high reliability.

The data were analyzed using descriptive and inferential statistics. Prior to hypothesis testing, normality and homogeneity of variance tests were conducted to assess the assumptions underlying the parametric analyses. The equivalence of initial abilities and differences in outcomes between the experimental and control groups were analyzed using an *independent samples t-test*. The achievement of mathematical communication mastery was examined using a *one-sample t-test* and a binomial proportion test. Furthermore, the predictive relationships between SAVIR implementation and students' mathematical communication skills and learning motivation were analyzed using simple linear regression with SPSS version 27. All statistical tests were conducted at a significance level of 0.05.

III. RESULTS AND DISCUSSION

A. Results

The results are presented based on the pretest and posttest data and the statistical analyses conducted to examine the effect of the SAVIR instructional model on sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. The analyses were conducted sequentially, beginning with an examination of the equivalence of the experimental and control groups' initial abilities, followed by individual and classical mastery analyses, a comparison of mathematical communication skills after the intervention, and regression analyses to examine the predictive relationships between SAVIR implementation and students' mathematical communication skills and learning motivation. The relevant statistical assumptions were examined before hypothesis testing according to the requirements of each analytical procedure.

Before the instructional treatments were implemented, both groups completed a mathematical communication pretest to establish their initial conditions and determine whether the groups differed significantly prior to receiving different instructional treatments. The results showed that Class VI A, which served as the experimental group, obtained a mean pretest score of 60.38, whereas Class VI B, which served as the control group, obtained a mean score of 60.42. The difference between the two means was only 0.04 points, descriptively indicating highly comparable levels of initial mathematical communication skills.

Table 2. Comparative Pretest Results of Mathematical Communication Skills in Classes VI A and VI B

Mastery Criterion	Category	VI A (F)	VI A (%)	VI B (F)	VI B (%)
>70	Mastery	3	14%	4	19%
<70	Non-mastery	19	86%	17	81%
Mean		60.38		60.42	

As presented in Table 2, most students in both groups had not achieved the mastery criterion at the initial measurement. In Class VI A, only 3 of 22 students (14%) achieved mastery, whereas 19 students (86%) had not yet reached the criterion. In Class VI B, 4 of 21 students (19%) achieved mastery, while 17 students (81%) were categorized as non-mastery. These descriptive findings were supported by the independent samples t-test, which yielded a Sig. (2-tailed) value of $0.932 > 0.05$. Thus, there was no statistically significant difference in initial mathematical communication skills between the two groups. These findings indicate that the experimental and control groups had relatively equivalent initial conditions before receiving different instructional treatments.

Following the implementation of SAVIR, the mathematical communication achievement of the experimental group was first examined in terms of individual mastery using a one-sample t-test, with the minimum mastery criterion of 70 as the test value. The posttest results showed that 20 of the 22 students (91%) achieved mastery, whereas only 2 students (9%) remained below the criterion. The experimental group obtained a mean posttest score of 81.09, which was 11.09 points above the established mastery criterion. The one-sample t-test yielded Sig. (2-tailed) < 0.001, which was below the significance level of 0.05. Therefore, the mean mathematical communication score of the experimental group was statistically higher than the reference value of 70. These findings demonstrate that students in the experimental group achieved the individual mastery criterion after participating in SAVIR-based learning.

In addition to mean-based individual mastery, classical mastery was examined using a binomial proportion test. Of the 22 students in the experimental group, 20 students, or 91%, achieved the established mastery criterion. The analysis yielded an Exact Sig. (1-tailed) value of <

0.001, indicating that the proportion of students achieving mastery was statistically greater than the 70% criterion specified in the study. Thus, the individual and classical mastery analyses demonstrated a consistent pattern, with the majority of students participating in SAVIR-based learning achieving the predetermined standard of mathematical communication skills.

An independent samples t-test was subsequently performed on the posttest scores to determine whether mathematical communication achievement differed between the two groups following instruction. The analysis yielded t = 3.104, df = 41, and Sig. (2-tailed) = 0.003 < 0.05, indicating a statistically significant difference in mean mathematical communication scores between the experimental and control groups. Descriptively, the experimental group obtained a mean score of 81.09, whereas the control group obtained a mean score of 72.29, representing a mean difference of 8.80 points in favor of the experimental group.

Table 3. Comparison of Posttest Results Between the Experimental and Control Groups

Mastery Criterion	Category	VI A (F)	VI A (%)	VI B (F)	VI B (%)
>70	Mastery	3	14%	4	19%
<70	Non-mastery	19	86%	17	81%
Mean		60.38		60.42	

As shown in Table 3, the difference between the two groups was evident not only in their mean scores but also in the distribution of students achieving mastery. In the experimental group, 20 of 22 students (91%) achieved the mastery criterion, compared with 13 of 21 students (62%) in the control group. Conversely, only 2 students (9%) in the experimental group did not achieve mastery, compared with 8 students (38%) in the control group. These descriptive findings are consistent with the results of the *independent samples t-test* and indicate that, following the instructional intervention, students participating in SAVIR-based learning demonstrated higher mathematical communication achievement than those receiving PBL instruction.

Simple linear regression was then conducted to examine the predictive relationship between SAVIR implementation and students' mathematical communication skills. Before conducting the regression analysis, normality and linearity assumptions were examined. The normality test yielded significance values of 0.197 for variable X and 0.363 for variable Y, both exceeding 0.05. The linearity test yielded a *Deviation from Linearity* significance value of 0.212 > 0.05. These results indicated that the assumptions of normality and linearity required for the regression analysis were satisfied.

The regression analysis yielded F = 15.269 with p < 0.001, indicating that the regression model was statistically significant. The R^2 value of 0.433 indicated that the regression model explained 43.3% of the variance in mathematical communication skills, while the remaining 56.7% was associated with variance not explained by the model. The regression coefficient for X was 1.339, indicating that a one-unit increase in the SAVIR predictor score was associated with a 1.339-unit increase in the mathematical communication score. Importantly, the coefficient of 1.339 should not be interpreted as a 133.9% increase, because an unstandardized regression coefficient represents the expected change in the dependent variable score associated with a one-unit change in the predictor rather than a percentage increase.

A simple linear regression analysis was also conducted to examine the predictive relationship between SAVIR implementation and students' learning motivation. The assumption tests yielded normality significance values of 0.130 for variable X and 0.186 for variable Y, both exceeding 0.05. The linearity test yielded a significance value of 0.689 > 0.05, indicating that the linearity assumption was satisfied. The subsequent regression analysis yielded F = 5.058 with p = 0.036 < 0.05, demonstrating that the regression model was statistically significant.

The R^2 value of 0.202 indicated that the regression model explained 20.2% of the variance in students' learning motivation, while the remaining 79.8% was not explained by the model. The regression coefficient for X was 0.191, indicating that a one-unit increase in the SAVIR predictor score was associated with a 0.191-unit increase in the learning motivation score. As with the previous analysis, the coefficient of 0.191 should not be interpreted as a 19.1% increase in learning motivation. Rather, it represents an expected increase of 0.191 units in the motivation score for every one-unit increase in the predictor score, assuming other conditions represented in the model remain constant.

Overall, the findings demonstrate a consistent pattern in mathematical communication achievement. The experimental and control groups exhibited relatively equivalent initial abilities; however, following instruction, the experimental group achieved a higher mean posttest score and a greater proportion of students reaching the mastery criterion than the control group. Inferential testing further confirmed a statistically significant difference between the groups. In addition, the regression analyses demonstrated significant predictive relationships between the SAVIR predictor scores and both mathematical communication skills and learning motivation. These findings provide the empirical basis for further discussion of how the pedagogical functions embedded within the SAVIR stages may be associated with students' mathematical communication and learning motivation.

B. Discussion

Based on the data analysis, the implementation of the SAVIR instructional model showed a positive effect on sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. This finding supports the conceptual framework of the study, which assumes that teacher-centered instruction, limited use of instructional media, and predominantly procedural exercises may constrain the development of mathematical communication and learning motivation. In contrast, SAVIR provides a more structured learning experience through the stages of Study of Case, Artificial Intelligence, Visualization with Augmented Reality, Interaction, and Reflection.

The findings showed that students' mathematical communication skills in the experimental group improved significantly after participating in SAVIR-based learning. The one-sample t-test yielded a significance value of < 0.001, with a mean posttest score of 81.09, indicating that the average mathematical communication score exceeded the minimum mastery criterion of 70. Descriptively, 20 of the 22 students, or 90.9%, achieved mastery, whereas 2 students, or 9.1%, did not. This result indicates a clear improvement following the intervention, reflected in students' greater ability to express mathematical ideas in writing, explain solution procedures, and communicate their reasoning systematically. These findings can be understood through the characteristics of SAVIR as an innovative instructional model that integrates learning experiences, exploration, technology, and social interaction within a systematic sequence. The model is consistent with cognitive and constructivist perspectives that position students as active constructors of knowledge through experience and interaction (Nugroho et al., 2025).

Classical mastery also reached a high level of 91% and statistically exceeded the 70% criterion, with an Exact Sig. (1-tailed) value of < 0.001. This indicates that mastery was not limited to a small number of students but was achieved by most students in the experimental group. One characteristic of SAVIR that may support this achievement is the use of AI as instructional scaffolding. Vygotsky's concept of the Zone of Proximal Development (ZPD) describes the gap between what students can accomplish independently and what they can achieve with assistance. Within SAVIR, AI can function as an adaptive source of support when students encounter difficulties in exploring information and solving problems.

Sulistya & Poerwanti (2020) also reported that constructivist approaches can enhance independence, curiosity, and intrinsic motivation because students are more actively involved in their learning processes. When students are given opportunities to explore, discuss, and use technological support actively, the resulting understanding may become more meaningful and contribute to higher levels of mastery. This finding can be compared with Lubis & Rahayu (2023), who found that students' mathematical communication skills through PBL were better than those achieved through Direct Instruction, although the improvement remained in the moderate category. In the present study, classical mastery in the SAVIR group reached 91%, suggesting that the integration of AR and AI provided additional instructional support not explicitly embedded within the conventional syntax of PBL.

The comparison of posttest results showed that the experimental group achieved higher mathematical communication scores than the control group taught using Problem-Based

Learning (PBL). The independent samples t-test yielded t = 3.104 with a significance value of 0.003, while the experimental group obtained a mean score of 81.09 compared with 72.29 in the control group. Mastery reached 91% in the experimental group and 62% in the control group. Within the context of this study, these differences indicate that SAVIR produced better learning outcomes than PBL. This advantage may be related to the additional visual support provided by AR and AI-based scaffolding, allowing students not only to solve problems but also to visualize objects more concretely, discuss mathematical ideas, and reflect on their reasoning processes. This is consistent with theoretical perspectives emphasizing the importance of visual representation, constructivism, and social interaction in developing mathematical understanding.

The relationship between SAVIR and mathematical communication skills was also supported by the simple linear regression analysis, which yielded F = 15.269 with $p < 0.001$. The R^2 value of 0.433 indicated that the regression model explained 43.3% of the variance in mathematical communication skills, while the remaining 56.7% was associated with other factors not included in the model. The positive regression coefficient of 1.339 indicated a positive relationship between SAVIR predictor scores and mathematical communication skills. This relationship may be explained through the function of each SAVIR stage: Study of Case engages students in analyzing contextual problems, AI supports information exploration, AR helps visualize abstract concepts, Interaction provides opportunities to communicate mathematical ideas, and Reflection encourages students to review their reasoning processes. These findings are consistent with previous studies showing that visual representation, AR, and interactive learning can support students in explaining procedures, connecting concepts, and communicating mathematical ideas more effectively.

The implementation of SAVIR also showed a significant relationship with students' learning motivation. The simple linear regression analysis yielded F = 5.058 with $p = 0.036$ and an R^2 value of 0.202. This indicates that the regression model explained 20.2% of the variance in learning motivation, while the remaining 79.8% was associated with other factors. Pedagogically, this finding may be related to the use of AR, which makes learning more visual, interactive, and engaging and may therefore increase students' attention and participation. Classroom observations also indicated that students became more active when they were given opportunities to explore three-dimensional geometric models visually and interactively. In this regard, learning motivation may be influenced not only by internal factors but also by the learning environment, instructional media, social interaction, and technological support.

This finding is supported by Hafis et al. (2024), who reported that the use of AR in learning can enhance intrinsic motivation through more realistic visualization and immersive learning experiences. Damayanti & Purwati (2024) likewise explained that interactive technology-based instructional media can increase students' attention, interest, and engagement during learning. However, Tari & Hutapea (2020) found that AR did not always produce significant improvement when students were unfamiliar with digital devices or when teacher guidance was insufficient. These contrasting findings indicate that the effectiveness of technology depends largely on how it is embedded within the instructional design and how interaction, scaffolding, and reflection are facilitated. In SAVIR, the Interaction and Reflection stages complement the functions of AI and AR so that technology is not used in isolation but becomes part of an integrated pedagogical process.

Overall, the findings indicate that the SAVIR instructional model was effective in supporting improvements in sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. These conclusions are supported by the statistical analyses, improvements in students' achievement after the intervention, higher outcomes in the experimental group, and consistency with relevant theoretical perspectives and previous studies. SAVIR can therefore be viewed as an integrative instructional model that not only helps students understand geometric concepts more concretely but also encourages them to communicate mathematical ideas more effectively and participate more actively in the learning process.

IV. CONCLUSION

Based on the findings, the SAVIR instructional model was effective in supporting improvements in sixth-grade students' mathematical communication skills and learning motivation in three-dimensional geometry. The analysis showed that the mean mathematical communication score of students in the experimental group exceeded the minimum mastery criterion, with both individual and classical mastery rates reaching more than 90%. In addition, a significant difference was found between students taught using SAVIR and those taught using *Problem-Based Learning* (PBL), with higher achievement observed in the SAVIR group. The integration of *Study of Case, Artificial Intelligence, Visualization with Augmented Reality, Interaction,* and *Reflection* provided a more concrete, active, and interactive learning experience. The regression analyses further indicated that the SAVIR model explained 43.3% of the variance in mathematical communication skills and 20.2% of the variance in students' learning motivation. These findings suggest that SAVIR has the potential to serve as an innovative AI- and AR-based instructional alternative for supporting more meaningful mathematics learning, particularly in three-dimensional geometry at the elementary school level.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest, financial or otherwise, that could have influenced the conduct, interpretation, or publication of this study.

AUTHOR CONTRIBUTIONS

Zefanya Melinda Cahyaningrum: *Conceptualization, Investigation, Data Collection, Formal Analysis, Writing – Original Draft, and Visualization.* ***Dani Kusuma:*** *Conceptualization, Methodology, Validation, Supervision, and Writing – Review & Editing. Both authors contributed to the interpretation of the findings, critically reviewed the manuscript, and approved the final version for publication.*

FUNDING

This research received no external funding.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to SD Negeri Kutowinangun 08 Salatiga for providing the opportunity, support, and facilities necessary for conducting this study. The authors also extend their appreciation to the academic supervisor for the guidance and valuable feedback provided throughout the research process, as well as to all sixth-grade students who actively participated and contributed to the successful completion of this study.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES

During the preparation of this manuscript, the authors used generative AI and AI-assisted technologies to support language editing, proofreading, and improvements in the clarity and readability of the manuscript. These technologies were not used to generate research data, perform statistical analyses, or determine the findings and conclusions of the study. All AI-assisted outputs were critically reviewed, revised, and verified by the authors. The authors take full responsibility for the accuracy, integrity, and content of the final manuscript.

REFERENCES

Adriani, N. N. L. P., Darmayanti, I. W. S., & Numertayasa, I. W. (2025). Implementasi Metode Perkalian dengan Metode Susun untuk Meningkatkan Hasil Belajar Matematika Siswa Sekolah Dasar. *Jurnal Inovasi, Evaluasi Dan Pengembangan Pembelajaran (JIEPP)*, *5*(2), 244–251. https://doi.org/10.54371/jiepp.v5i2.992

Arafah, F. N., Sumarno, S. ., Rahayu, L. P., & Untari, M. F. A. (2024). Analisis Aktivitas Belajar Matematika Siswa pada Model Kooperatif Tipe Student Teams Achievement Division (STAD) di Sekolah Dasar. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, *5*(4), 475–483. https://doi.org/10.54371/ainj.v5i4.632

Asmedy, A. (2021). Perbedaan Hasil Belajar Siswa yang Diajar Menggunakan Model Pembelajaran Soal Terbuka dengan Model Pembelajaran Konvensional. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, *2*(2), 79–88. https://doi.org/10.54371/ainj.v2i2.36.

Aulia, K. M., & Surya, E. (2023). Peranan Kemampuan Komunikasi Matematis untuk Mengembangkan Ide dan Cara Berpikir Kritis. *Researchgate*, *2*(2), 1–10

Cahya, M. D., Pamungkas, Y., Faiqoh, E. N., Studi, P., Profesi, P., Jember, U. M., Technology, M., & Nopember, S. (2023). *Analisis Karakteristik Siswa sebagai Dasar Pembelajaran Berdiferensiasi terhadap Peningkatan Kolaborasi Siswa Analysis of Students ' Characteristic as the Basis for Differentiated Learning to Improved Student Collaboration*. *75*, 31–45. https://doi.org/10.32528/bioma.v8i1.372

Damayanti, R., & Purwati, P. D. (2024). Penerapan Model Problem Based Learning dengan Bantuan Media "Cube AR" Kubus Satuan Bermuatan Augmented Reality dalam Peningkatan Pemahaman Siswa pada Materi Volume Kelas V. *Penerapan Media Cube AR (Rita Damayanti) Madani: Jurnal Ilmiah Multidisiplin*, *38*(5), 38–42. https://doi.org/10.5281/zenodo.11284860

Dewi, U. K., Subekti, E., & Rahayu, R. (2024). Efektivitas Media Papan Pintar terhadap Hasil Belajar Siswa Kelas II Sekolah Dasar. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, *5*(4), 519–525. https://doi.org/10.54371/ainj.v5i4.652

Hafis, Buhaerah, & Kasmirah. (2024). Implementasi Media Pembelajaran Berbasis Augmented Reality Untuk Meningkatkan Pemahaman Konsep Geometri Siswa. *Jurnal Pendidikan Matematika*, *5*(2), 1–8. https://jurnal.habi.ac.id/index.php/Dikmat

Hardianti, I., Murniati, N. A. N., Poncowati, L., & Purnamasari, I. (2025). Implementasi Model Pembelajaran Problem Basic Learning untuk meningkatkan Hasil Belajar Matematika Siswa Kelas IV Sekolah Dasar. *Jurnal Inovasi, Evaluasi Dan Pengembangan Pembelajaran (JIEPP)*, *5*(1), 40–46. https://doi.org/10.54371/jiepp.v5i1.650

Masyhudah, M. S., & Widyasari, C. . (2024). Penerapan Model Pembelajaran Cooperative Learning Tipe STAD untuk Meningkatkan Hasil Belajar Matematika Siswa Kelas V. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, *5*(4), 526–532. https://doi.org/10.54371/ainj.v5i4.655

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

National Council of Teachers of Mathematics. (2014). Principles to actions: Ensuring mathematical success for all. National Council of Teachers of Mathematics. Publikasi NCTM ini memberikan landasan primer yang lebih kuat daripada sumber sekunder untuk praktik pembelajaran matematika.

Ningsih, N., Bunga, M. H. D., & Bera, L. (2025). Pengaruh Model Pembelajaran Problem Based Learning berbantuan Media Kartu Desimal War terhadap Hasil Belajar Matematika Siswa. *Ainara Journal (Jurnal Penelitian Dan PKM Bidang Ilmu Pendidikan)*, *6*(2), 197–203. https://doi.org/10.54371/ainj.v6i2.827

OECD. (2019). PISA 2018 results (Volume I): What students know and can do. OECD Publishing. doi:10.1787/5f07c754-en. Ini harus menggantikan rujukan "Know & Do, 2018" pada naskah. OECD menerbitkan Volume I PISA 2018 pada 2019.

Rizki, S., Sarifah, I., & Yunus, M. (2025). Analisis Learning Obstacle Materi Geometri Pada Siswa Kelas Iv Sekolah Dasar. *Pedagogy: Jurnal Pendidikan Matematika*, *10*(2), 501–512. https://doi.org/10.30605/pedagogy.v10i2.5950

Royani, I., & L, E. N. (2020). Studi Literatur Tentang Model Pembelajaran Berbasis Teori Van Hiele Terhadap Kemampuan Komunikasi Matematis Siswa Sekolah Dasar. *PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *7*(2), 93–108. https://doi.org/10.17509/pedadidaktika.v7i2.25125

Santoso, E. (2022). Penggunaan Model Pembelajaran Kontekstual Untuk Meningkatkan Kemampuan Pemahaman Matematika Siswa Sekolah Dasar. *Jurnal Cakrawala Pendas*, *3*(1). https://doi.org/10.31949/jcp.v3i1.407

Saputra, H. D., Purwanto, W., Setiawan, D., Fernandez, D., & Putra, R. (2022). *HASIL BELAJAR MAHASISWA : ANALISIS BUTIR SOAL TES pembelajaran sebagai upaya meningkatkan hasil belajar mahasiswa . Efektivitas*. *20*, 15–27.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin. Referensi ini dapat digunakan untuk memperkuat dasar metodologis desain kuasi eksperimen yang dipakai dalam penelitian.

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds.). Harvard University Press. Ini sebaiknya digunakan sebagai sumber primer ketika membahas ZPD, interaksi sosial, dan scaffolding.