

Enhancing Student's Problem-Solving and Collaboration Skills through Learning Media in Pythagorean Theorem Lessons

Maya Puspita Artasari¹, Wahyu Setyaningrum²

^{1,2} Yogyakarta State University, Yogyakarta, Indonesia

ARTICLE INFO

Published Online:
30 September 2025

Corresponding Author:
Maya Puspita Artasari

ABSTRACT

In the digital era, mathematics learning must not only focus on conceptual understanding but also foster essential 21st-century skills such as problem-solving and collaboration. However, classroom practices often remain teacher-centered, limiting students' active participation. This study aimed to analyze the effectiveness of interactive learning media in improving students' problem-solving and collaboration skills in the Pythagorean Theorem. A quantitative approach with a pre-experimental one-group pretest-posttest design was applied to 31 eighth-grade students at SMP Negeri 3 Kalasan. Data were collected using problem-solving tests, collaboration questionnaires, and observation sheets, and analyzed through descriptive statistics and paired sample t-tests. The findings revealed significant improvement in both problem-solving and collaboration after the intervention, indicating that interactive media can create a more engaging and student-centered learning environment. These results confirm the potential of technology-assisted learning to strengthen students' cognitive and social competencies. It can be concluded that interactive learning media are effective in enhancing mathematics learning outcomes, though challenges such as maintaining student focus and motivation remain.

KEYWORDS: Problem Solving, Collaboration, Learning Media, Pythagorean Theorem

INTRODUCTION

Education in the era of globalization and digitalization demands more than just academic achievement. Students are also required to master 21st-century skills such as critical thinking, problem-solving, communication, and collaboration. This has driven a shift in the learning paradigm from teacher-centered to student-centered approaches that are active, participatory, and meaningful.

Mathematics, as one of the core subjects, plays a crucial role in developing higher-order thinking skills. However, in practice, mathematics learning in schools is often still one-directional, focusing on memorization of formulas and mechanical procedures, without providing sufficient space for conceptual understanding, problem-solving, or student collaboration. As a result, many students struggle to apply mathematical concepts in real-life situations.

One of the essential competencies in mathematics learning is problem-solving ability. According to the NCTM (2000), this ability lies at the heart of mathematics education as it involves understanding concepts, formulating strategies, and reflecting on the solutions obtained. However, the 2022 PISA report shows that Indonesian students still lag behind in this regard, particularly in solving contextual and unfamiliar problems (OECD, 2023). This indicates the need for learning approaches that emphasize students' active engagement in thinking processes and problem-solving.

Moreover, collaboration is also a vital skill that needs to be fostered through learning. In the context of mathematics, collaboration helps students engage in discussions, exchange ideas, and build understanding through meaningful social interaction. Unfortunately, mathematics is often perceived as an individualistic subject, which limits opportunities for collaboration. In fact, collaboration has been shown to improve mathematical communication, self-confidence, and the overall quality of student understanding (Pozzi et al., 2023; Salva et al., 2024).

In mathematics education, collaboration emerges as a promising strategy not only for deepening conceptual understanding, but also for enhancing communication skills, critical thinking, and teamwork. Collaborative learning creates opportunities for students to interact, discuss, and build shared understanding through social engagement.

Pozzi et al. (2023), in *Education Sciences*, emphasize that well-designed collaborative learning especially when supported by technology can enrich the learning experience and improve the quality of student interaction. This is supported by Salva et al. (2024), whose findings demonstrate that the implementation of a GeoGebra-assisted Collaborative Problem-Solving model significantly enhances students' communication skills and self-confidence. However, in practice, collaboration does not always occur naturally, particularly in mathematics classes that are often dominated by individual work. Thus, there is a need for

instructional designs and learning media that are intentionally developed to promote social interaction during the learning process.

To support active, collaborative, and problem-based learning, the use of interactive, technology-based learning media offers a promising solution. Tools such as GeoGebra, Desmos, and various interactive applications have proven effective in helping students grasp abstract mathematical concepts, especially in geometry. When properly used, these tools can simultaneously foster both cognitive and social engagement among students.

The Pythagorean Theorem is one mathematics topic that is well-suited for this approach. As a fundamental concept in right triangle geometry, it has numerous real-world applications, such as measuring distances, construction, and navigation. However, studies such as Sugiarni et al. (2022) have shown that students still struggle to understand this concept, particularly in visualizing the relationship between the sides and grasping the idea of squares in geometric contexts.

The use of visual and interactive learning media has been shown to help overcome these difficulties. Zalsabillah et al. (2024) found that interactive media use in teaching the Pythagorean Theorem significantly improved students' mathematical communication. Nonetheless, most existing studies have focused on improving individual understanding, with limited investigation into how learning media can effectively promote active collaboration and systematic problem-solving in mathematics education.

Furthermore, Sugiarni et al. (2022) emphasized that many students still struggle with understanding the relationships between the sides of right triangles in the Pythagorean Theorem. This difficulty stems from limited spatial imagination and insufficient mastery of the square concept, often exacerbated by non-contextual and non-interactive teaching approaches. In this regard, visual learning media play a critical role in helping students concretely and dynamically visualize mathematical concepts.

Based on the discussion above, it can be concluded that mathematics learning especially on the topic of the Pythagorean Theorem still faces various challenges, including poor conceptual understanding, limited problem-solving ability, and low levels of collaborative engagement. At the same time, various studies indicate that collaborative approaches supported by interactive learning media can improve the effectiveness of instruction, particularly in terms of communication, visual understanding, and problem-solving skills.

However, most available learning media are still designed for individual use and have not been explicitly structured to foster active student collaboration. Therefore, it is important to examine the effectiveness of the learning media used in encouraging both cognitive and social engagement particularly in improving students' problem-solving skills and collaboration on the topic of the Pythagorean Theorem.

RESEARCH METHOD

This research is a quantitative study using the experimental method. The experimental method is a research method used to determine the effect of a certain treatment (Sugiyono, 2017). The type of research design used in this study is a Pre-Experimental Design with a one-group pretest-posttest design. The reason the researcher used this design is that in this study, the researcher could not fully

control external variables that might influence the implementation of the experiment. The researcher only used one sample class.

This research was conducted in class VIII-B of SMP Negeri 3 Kalasan during the even semester in the mathematics subject, focusing on the application of the Pythagorean theorem. The population in this study was all students of class VIII-B at SMP Negeri 3 Kalasan. The sample consisted of 31 students from class VIII-B at SMP Negeri 3 Kalasan. The sampling technique used in this study was Purposive Sampling.

The data collection techniques used in this study were observation sheets, problem-solving tests, and collaboration questionnaires. The data analysis in this study employed the paired sample t-test and descriptive analysis. The criteria for assessing the achievement of problem-solving and collaboration skills can be seen in Table 1.

Table 1. Criteria For The Achievement of Students’ Problem-Solving and Collaboration Learning Outcomes

Category	Interval Score	
	Problem Solving	Collaboration
Very Good	$x > 80$	$x > 63$
Good	$60 < x \leq 80$	$51 < x \leq 63$
Pair	$40 < x \leq 60$	$39 < x \leq 51$
Very Poor	$20 < x \leq 40$	$27 < x \leq 39$
Poor	$x \leq 20$	$x \leq 27$

RESULT AND DISCUSSION

After implementing learning assisted by instructional media in class VIII-B of SMP Negeri 3 Kalasan, there was an improvement in students’ problem-solving and collaboration skills. The results of student’s problem-solving achievement are presented in Table 2.

Table 2. Student’s Problem Solving Achievement Results

Statistics	Pre Test	Post Test
Mean Score	54,29	87,90
Standard Deviation	10,46	9,1
Max Score	70	100
Min Score	40	73

Based on the results in Table 2, it shows that the pretest and posttest scores increased by 33.61, with the average pretest score being 54.29 and the posttest score being 87.90, which means $x > 80$, categorized as very good. The results of student’s collaboration achievement are presented in Table 3.

Table 3. Student’s Collaboration Achievement Results

Statistics	Pre Test	Post Test
Mean Score	40,42	65,52
Standard Deviation	6,30	6,41
Max Score	50	75
Min Score	30	51

Based on the results in Table 3, it shows that the pretest and posttest scores increased by 25.1, with the average pretest

score being 40.42 and the posttest score being 65.52, which means $x > 63$, categorized as very good.

From all the above results, it can be concluded that there was a significant improvement after the implementation of learning assisted by instructional media. Next, the data were analyzed using the Shapiro-Wilk test as a prerequisite for the paired sample t-test. The results of the Shapiro-Wilk test can be seen in Figure 1.

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Problem Solving	.128	31	.200*	.916	31	.018
Problem Solving	.139	31	.129	.915	31	.018
Collaboration	.110	31	.200*	.929	31	.042
Collaboration	.147	31	.088	.952	31	.177

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Figure 1. One-Sample Shapiro-Wilk Test

In Figure 1, the sig. value was greater than 0.05, thus it can be concluded that the data were normally distributed. Next, the paired sample t-test was conducted. The results of the paired sample t-test can be seen in Figure 2.

	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
				Lower	Upper			
Pair 1 Problem Solving - Problem Solving	-29.83871	14.18473	2.54765	-35.04171	-24.63571	-11.712	30	.000
Pair 2 Collaboration - Collaboration	-22.09677	9.29285	1.86904	-25.50542	-18.68813	-13.239	30	.000

Figure 2. Paired Sample Test

In Figure 2, it can be seen that the sig. (2-tailed) value is 0.000, which means it is less than 0.05. Thus, it can be concluded that the average post-test scores of students’ problem-solving and collaboration are higher than their pre-test scores.

Based on the data analysis conducted by testing the prerequisites, it was found that the data were normally distributed. Subsequently, a paired sample t-test was carried out to determine whether learning assisted by instructional media was effective in improving problem-solving and collaboration skills of class VIII-B students at SMP Negeri 3 Kalasan. After conducting the normality test, which showed that the data were normally distributed, the paired sample t-test was performed and yielded a sig. value of $0.000 < 0.05$. Thus, it can be concluded that the average problem-solving and collaboration scores of class VIII-B students at SMP Negeri 3 Kalasan, which exceeded 73 and 51 which are the minimum mastery scores respectively, can be accepted. Therefore, instructional media-assisted learning is effective in enhancing students’ problem-solving and collaboration skills in this class.

There were, however, several factors beyond the researcher’s control, such as students’ lack of focus and reluctance to complete the given tasks. During the learning process, it was found that some students were able to complete the tasks given by the researcher and achieve the indicators of problem-solving and collaboration tests.

CONCLUSION

The implementation of instructional media-assisted learning in class VIII-B of SMP Negeri 3 Kalasan has been proven to improve students’ problem-solving and collaboration skills. After participating in the learning process, students demonstrated better progress in solving problem-solving tasks and were able to work more effectively in groups. The statistical analysis also supports these findings, showing a significant difference between the results before and after the learning intervention. Thus, the use of instructional media can be considered effective in enhancing students’ learning quality, although some challenges remain in its implementation, such as lack of focus and motivation among certain students.

REFERENCES

- [1] Al-Amin, Y., & Hartono, H. (2024). How multimedia learning enhances students' mathematical creativity in science education: A meta-analysis study. *Jurnal Penelitian Pendidikan IPA*, 10(5), 234–241. <https://doi.org/10.29303/jppipa.v10i5.5273>
- [2] Ariani, N., Sari, P. K., & Santoso, D. (2024). Penerapan model pembelajaran kontekstual untuk meningkatkan pemahaman konsep matematika siswa. *Jurnal Pendidikan Matematika dan Sains*, 8(1), 55–63.
- [3] Bowman, M., Debray, S. K., and Peterson, L. L. 1993. Reasoning about naming systems.
- [4] Brown, L. D., Hua, H., and Gao, C. 2003. A widget framework for augmented interaction in SCAPE.
- [5] Forman, G. 2003. An extensive empirical study of feature selection metrics for text classification. *J. Mach. Learn. Res.* 3 (Mar. 2003), 1289-1305.
- [6] Fröhlich, B. and Plate, J. 2000. The cubic mouse: a new device for three-dimensional input. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*.
- [7] National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.
- [8] Noverianto, I., Agoestanto, A., Dewi, K. S., & Mariani, D. (2024). Meta-analysis: The effect of the Geogebra applet-assisted discovery learning model on students’ mathematical problem-solving ability in geometry material. *Mathline: Jurnal Matematika dan Pendidikan Matematika*, 9(1), 45–56.
- [9] OECD. (2023). *Innovating Education and Educating for Innovation*. OECD.
- [10] Polya, G. (1957). *How to Solve It: A New Aspect of Mathematical Method*. Princeton, NJ: Princeton University Press.
- [11] Pozzi, F., Manganello, F., & Persico, D. (2023). Collaborative learning: A design challenge for teachers. *Education Sciences*, 13(4), 331. <https://doi.org/10.3390/educsci13040331>
- [12] Putri, V. A., Aziz, A., & Suprayitno, I. J. (2025). Development of T-Solve interactive learning media with Polya approach on Pythagorean theorem. *Juwara:*

Jurnal Wawasan dan Aksara, 5(1), 81–98.
<https://doi.org/10.58740/juwara.v5i1.401>

- [13] Riansyah, D. W., Choirudin, C., & Anwar, M. S. (2024). Peningkatan hasil belajar matematika dengan model kooperatif TGT untuk Teorema Pythagoras. *Assyfa Journal of Multidisciplinary Education*, 1(2), 147–152. <https://doi.org/10.61650/ajme.v1i2.544>
- [14] Salva, H. A., Hamidah, N., Ayuningtyas, R., & Kusuma, R. (2024). Implementation of the collaborative problem-solving learning model using GeoGebra on the mathematical communication ability and confidence of MTS Islamiyah Ciomas students. *Indonesian Journal of Elementary and Early Childhood Education*, 3(1), 22–33.
- [15] Sannella, M. J. 1994 Constraint Satisfaction and Debugging for Interactive User Interfaces. Doctoral Thesis. UMI Order Number: UMI Order No. GAX95-09398., University of Washington.
- [16] Santoso, A. N., Salsabila, E., & Haeruman, L. D. (2022). Pengembangan media pembelajaran interaktif berbasis Android dengan model discovery learning pada materi Teorema Pythagoras kelas VIII SMP Negeri 20 Jakarta. *Jurnal Riset Pembelajaran Matematika Sekolah*, 6(2), 98–108.
- [17] Spector, A. Z. 1989. Achieving application requirements. In *Distributed Systems*, S. Mullende
- [18] Sugiarni, R. A., Ariyanti, L., & Aulia, R. (2022). Pengembangan media visual berbasis teknologi menggunakan software GeoGebra pada materi Teorema Pythagoras. *Sigma Didaktika: Jurnal Pendidikan Matematika*, 5(2), 101–109.
- [19] Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung : Alfabeta, cv.
- [20] Tavel, P. 2007 *Modeling and Simulation Design*. AK Peters Ltd.
- [21] UNESCO. (2022). *Reimagining our futures together: A new social contract for education*. United Nations Educational, Scientific and Cultural Organization.
- [22] Y.T. Yu, M.F. Lau, "A comparison of MC/DC, MUMCUT and several other coverage criteria for logical decisions", *Journal of Systems and Software*, 2005, in press.
- [23] Zalsabillah, F., Putri, S. N., & Septy, A. (2024). The effectiveness of using GeoGebra media in Pythagoras learning on students' mathematical communication skills. *Jurnal Inovasi Matematika (JIM)*, 3(2), 45–52.
- [24] Zarkasyi, W. (2017). *Penelitian Pendidikan Matematika*. Bandung : PT Refika Aditama.