JURNAL ABSIS
Jurnal Pendidikan Matematika dan Matematika
Vol. 9 No. 2, August 2026

The Use of Mathematics Comics in a Problem-Based Learning Model on Students' Mathematical Communication Ability

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Received: July 7, 2026 | **Revised:** August 16, 2026 | **Accepted:** August 17, 2026 | **Published:** August 29, 2026

ABSTRACT This study aimed to determine the effect of integrating mathematics comics into the Problem-Based Learning (PBL) model on students' mathematical communication ability. The population consisted of all eighth-grade students at SMP Negeri 4 Bandar Lampung during the second semester of the 2025/2026 academic year, distributed across ten classes (VIII-A to VIII-J). The sample was selected using cluster random sampling, resulting in Class VIII-F as the experimental class with 28 students and Class VIII-I as the control class with 28 students. This study employed a pretest–posttest control group design. The experimental class was taught using the PBL model integrated with mathematics comics, while the control class was taught using the PBL model without mathematics comics. The quantitative data consisted of N-Gain scores obtained from pretests and posttests measuring students' mathematical communication ability. The Mann–Whitney U test yielded $Z = -4.15$, indicating that the improvement in the experimental class was significantly greater than that in the control class. These findings demonstrate that integrating mathematics comics into the PBL model significantly improves students' mathematical communication ability.

Keywords: mathematics comics, mathematical communication ability, problem-based learning

INTRODUCTION

Mathematics is a compulsory subject at both the primary and secondary levels of education. It plays an essential role in developing students' logical, systematic, and analytical thinking abilities, which are necessary not only for academic success but also for solving problems encountered in everyday life (Government Regulation of the Republic of Indonesia No. 4 of 2022). According to the Center for Curriculum and Learning Standards (BSKAP, 2024), mathematics learning has six main objectives. Among these objectives, mathematical communication ability is considered a fundamental competency that every student should develop to achieve the goals of mathematics education.

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Mathematical communication ability refers to students' ability to express mathematical ideas through language, notation, or mathematical symbols, enabling them to understand, interpret, and solve contextual problems by representing them in mathematical models, both orally and in writing (Lubis et al., 2023). Purnamasari and Afriansyah (2021) further emphasized that mathematical communication is the ability to understand and express facts, ideas, and thoughts in ways that enable others to comprehend them. Moreover, mathematical communication helps students connect abstract mathematical ideas and concepts with various forms of representation, including symbols, diagrams, graphs, and mathematical language. It also provides opportunities for students to express their ideas verbally and in writing while actively participating in discussions with peers and teachers, thereby fostering more meaningful conceptual understanding (Novitasari et al., 2024). Thus, mathematical communication ability can be defined as the ability to communicate mathematical ideas effectively through various forms of representation to facilitate understanding and problem solving.

Mathematical communication ability plays a crucial role in mathematics learning because it enables students to express, develop, and clarify mathematical ideas while strengthening their conceptual understanding (NCTM, 2000; Hafriani, 2021). Hodiyanto (2017) classified mathematical communication ability into three main indicators: written text, drawing, and mathematical expression. The written text indicator refers to students' ability to explain concepts or problem-solving procedures in their own words. The drawing indicator concerns the ability to represent mathematical ideas visually, while mathematical expression refers to the ability to translate problems into mathematical language or models.

In practice, however, Indonesian students' mathematical communication ability still requires significant improvement. This condition is reflected in the results of the Trends in International Mathematics and Science Study (TIMSS) 2015, the Programme for International Student Assessment (PISA) 2022, and the Minimum Competency Assessment (MCA), which has been implemented by the Indonesian government since 2021. These assessments consistently indicate that Indonesia remains in a low performance category in mathematical communication. Consistent with these findings, studies conducted by Sholehah et al. (2022) and Yusuf and Ratnaningsih (2022) revealed that many students continue to experience difficulties in translating contextual problems into mathematical models and analyzing information presented in graphs, diagrams, and tables. These findings indicate that mathematics instruction should facilitate the development of mathematical communication ability through learning activities that encourage students to understand, represent, and communicate mathematical ideas effectively.

Low mathematical communication ability was also identified at SMP Negeri 4 Bandar Lampung. A preliminary test consisting of two essay questions was administered to 27

students in one class. The results indicated that many students experienced difficulties in expressing mathematical ideas orally and in writing, particularly in the written text and drawing indicators. They also struggled to represent problems using appropriate diagrams, symbols, or mathematical expressions, indicating difficulty with the mathematical expression indicator. To address this issue, an instructional model that actively engages students in problem solving is needed. Through problem-solving activities, students become directly involved in the learning process (Warsono & Hariyanto, 2012). One instructional model considered suitable for promoting such engagement is Problem-Based Learning (PBL) (Suwanti & Maryati, 2021). PBL encourages students to participate actively while developing communication, critical thinking, collaboration, and problem-solving abilities (Nurhanurawati et al., 2026).

Problem-Based Learning (PBL) is a student-centered instructional model that emphasizes solving authentic real-world problems. According to Widiasworo (2018), PBL presents students with problems derived from everyday situations, encouraging them to actively seek appropriate solutions. This model facilitates the development of mathematical communication ability because students must understand contextual problems and translate them into mathematical language and symbols, which requires effective mathematical communication (Corebima et al., 2020). According to Arends (2012), the implementation of PBL consists of five stages: (1) orienting students to the problem, (2) organizing students for learning, (3) guiding individual and group investigations, (4) developing and presenting the results, and (5) analyzing and evaluating the problem-solving process. Accordingly, Sinaga and Manik (2019) found that PBL can effectively improve students' mathematical communication ability. Similarly, Layliyyah et al. (2022) reported that PBL significantly enhances students' mathematical communication abilities.

In addition to an appropriate instructional model, improving students' learning outcomes and knowledge requires engaging learning media that encourage active participation. One medium that effectively promotes active learning is comics (Subroto et al., 2020; Aji & Mampouw, 2019; Fadella & Prabowo, 2018). Subroto et al. (2020) found that comics positively affect classroom learning because they combine visual illustrations with text, making learning materials more attractive and easier to understand. Comics also encourage students to become actively involved by presenting stories related to familiar everyday problems. In addition to improving learning outcomes, comics can increase students' motivation and interest in learning (Saputro, 2016). Such visually engaging media are particularly appealing to junior secondary school students, who often prefer visual learning materials. As stated by Tavares et al. (2023), comics are an effective visual communication medium that can convey information efficiently while supporting interactions between students and instructional materials. Learning through comics stimulates students' curiosity about the stories presented, thereby motivating them to continue learning.

As instructional media, comics can present content that is closely related to students' daily experiences (Apostolou & Linardatos, 2023). Their use in education can increase students' interest in reading while helping them understand content through the integration of written text and visual illustrations (Robbani & Khoirotunnisa, 2021). Cohn (2013) identified four essential elements of comic design: space, image, text, and colour. These features make comics communicative and efficient and can increase students' learning motivation. By interpreting illustrated stories, students can more easily identify problems presented in learning situations. Therefore, integrating comics into problem-based learning is expected to enhance students' interest while creating an innovative, constructive, meaningful, and enjoyable learning environment that ultimately improves their mathematical communication ability.

Although previous studies have shown that comics can positively affect the learning process, improve learning outcomes, and encourage student engagement and interest, research on the systematic integration of mathematics comics into each stage of Problem-Based Learning (PBL) remains limited, particularly for the Pythagorean Theorem. Previous studies have primarily examined comics as a general learning medium and have not specifically demonstrated how they can be integrated into each stage of PBL to support students' problem-solving processes and mathematical communication ability. Therefore, this study integrates mathematics comics into each stage of the PBL model for the Pythagorean Theorem and examines their effect on students' mathematical communication ability.

Based on the foregoing discussion, this study investigated the effect of integrating mathematics comics into the Problem-Based Learning model on students' mathematical communication ability. Specifically, mathematics comics were implemented at every stage of the Problem-Based Learning process. The findings are expected to provide a valuable reference for mathematics instruction, particularly regarding the effectiveness of this integration in improving students' mathematical communication ability.

RESEARCH METHOD

The population consisted of all eighth-grade students at SMP Negeri 4 Bandar Lampung, comprising ten classes (VIII-A through VIII-J). Using cluster random sampling, two classes were selected: Class VIII-F as the experimental group, which received instruction through the Problem-Based Learning (PBL) model integrated with mathematics comics, and Class VIII-I as the control group, which received instruction through the PBL model without mathematics comics.

This study employed a quasi-experimental pretest–posttest control group design involving an independent and a dependent variable. The independent variable was the implementation of the PBL model integrated with mathematics comics, while the dependent variable was students' mathematical communication ability. The experimental class

was taught using the PBL model integrated with mathematics comics, while the control class was taught using the PBL model without mathematics comics. Both classes received instruction on the Pythagorean Theorem over five meetings. Each meeting consisted of two lesson periods (2 JP), and both classes received the same learning material. The quantitative data consisted of students' mathematical communication ability scores obtained before and after the intervention using a test administered as a pretest and posttest.

Table 1. Recapitulation of Test Instrument Trial Results

Item	Validity	Reliability	Discrimination Index	Difficulty Level	Conclusion
1			0.24 (Adequate)	0.42 (Moderate)	
2	Valid	0.78 (Reliable)	0.24 (Adequate)	0.39 (Moderate)	Usable
3			0.38 (Adequate)	0.31 (Moderate)	

The instrument was a mathematical communication ability test developed based on three indicators: written text, drawing, and mathematical expression. It consisted of three essay questions designed to measure students' mathematical communication ability. Before administration, the instrument underwent content validation by experts to ensure that the test items were aligned with the indicators being measured. Based on this assessment, the instrument was declared valid. The trial scores ranged from 7 to 28. As shown in Table 1, the instrument had a reliability coefficient of $0.78 > 0.70$, indicating acceptable reliability. Test Items 1, 2, and 3 had discrimination indices of 0.24, 0.24, and 0.38, respectively. These values fell within the range of 0.21–0.40, indicating adequate discrimination. The items had difficulty indices of 0.42, 0.39, and 0.31, respectively, which fell within the range of 0.31–0.70 and indicated moderate difficulty. Thus, all test items were valid and reliable, demonstrated appropriate discrimination and difficulty levels, and were considered suitable for assessing students' mathematical communication ability.

The data were analyzed statistically using students' N-Gain scores in mathematical communication ability. Before hypothesis testing, a prerequisite analysis was conducted. The chi-square normality test indicated that the experimental group's N-Gain scores had a test statistic of $\chi^2_{\text{calculated}} = 13.240 > \chi^2_{\text{critical}} = 7.815$, while the control group's scores had a test statistic of $\chi^2_{\text{calculated}} = 8.665 > \chi^2_{\text{critical}} = 7.815$. Because the data were not normally distributed, the research hypothesis was tested using the nonparametric Mann–Whitney U test.

The Mann–Whitney U test yielded $U = 645.5$, $\mu_U = 392$, and $\sigma_U = 61.01$, resulting in $Z = -4.15$, while the critical value was $Z = -1.64$. Because the calculated value was less than the critical value ($-4.15 < -1.64$), the null hypothesis (H_0) was rejected. Therefore, the median N-Gain score for students' mathematical communication ability in the group taught through the PBL model integrated with mathematics comics was

significantly higher than that of the group taught through the PBL model without mathematics comics.

RESULTS AND DISCUSSION

Students' N-Gain scores for mathematical communication ability were derived from their pretest and posttest scores. These data were used to determine the improvement in the experimental and control classes. The N-Gain formula, according to Hake (as cited in Rista et al., 2019), is as follows.

$$\text{N-Gain} = \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}}$$

A summary of students' N-Gain scores in mathematical communication ability is presented in Table 2.

Table 2. Summary of N-Gain Scores in Mathematical Communication Ability

Class	n	Lowest N-Gain	Highest N-Gain	Mean	Standard Deviation
Experimental	28	0.22	0.93	0.65	0.22
Control	28	0.09	0.77	0.39	0.18

Maximum possible N-Gain = 1.00

As shown in Table 2, the mean N-Gain in mathematical communication ability for the experimental class was higher than that of the control class, indicating greater improvement. The higher standard deviation in the experimental class also indicates greater variation in improvement than in the control class. The achievement of mathematical communication indicators before and after instruction in both classes is presented in Table 3.

Table 3. Achievement Percentages for Mathematical Communication Ability Indicators

Indicators	Experimental		Control	
	Before	After	Before	After
Drawing	18.45%	72.92%	20.54%	57.44%
Written Text	13.10%	65.56%	16.37%	41.96%
Mathematical Expression	17.26%	70.54%	16.67%	52.98%
Average	16.27%	70.34%	17.86%	50.79%

As shown in Table 3, the mean initial achievement of the mathematical communication indicators in the experimental group was lower than that of the control group. However, the experimental group taught through the Problem-Based Learning (PBL) model integrated with mathematics comics achieved higher final scores for each indicator than the control group taught through the PBL model without mathematics

comics. The greatest improvement occurred in the drawing indicator, which increased by 54.47% in the experimental group, 17.57 percentage points more than in the control group. These findings indicate that students became better able to transform verbal descriptions of mathematical problems into relevant visual representations. Mathematics comics strengthened students' ability to visualize mathematical problems, enabling them to represent or redraw situations and geometric forms according to the given context.

Overall, the data analysis revealed that the improvement in mathematical communication ability among students taught through the PBL model integrated with mathematics comics was greater than that of students taught through the PBL model without mathematics comics. This pattern was consistent across all indicators, with the experimental group outperforming the control group. Furthermore, hypothesis testing demonstrated that integrating mathematics comics into the PBL model had a significant effect on students' mathematical communication ability. These findings are consistent with those of Marlina et al. (2023), who reported that integrating comics into PBL has the potential to improve students' mathematical communication ability. Similarly, Amalia and Nugraheni (2024) concluded that PBL-based comics are effective in enhancing students' mathematical communication ability.

The greater improvement observed in the experimental group may be attributed to the integration of mathematics comics throughout each stage of the PBL process. Unlike students in the control group, who encountered contextual problems only through written worksheets, students in the experimental group encountered problems through illustrated stories. This presentation enabled them to understand the problem context more easily, identify essential information, and relate mathematical concepts to real-life situations. Moreover, the visual representations facilitated the expression of mathematical ideas, construction of mathematical models, and communication of problem-solving processes. Fikriani and Nurva (2020) similarly reported that comic-based mathematics learning media effectively improve students' mathematical communication ability. These findings are further supported by Jazuli et al. (2024), who found that mathematics comics integrated into PBL effectively enhance students' mathematical communication ability.

More specifically, the first stage of PBL involves orienting students to the problem. During this stage, students were introduced to contextual problems through mathematics comics, making it easier for them to understand the context of the Pythagorean Theorem. The combination of stories and illustrations helped students identify known and unknown information while connecting it to previously learned mathematical concepts. Through these activities, students began communicating mathematical ideas in written form, visual representations, and mathematical symbols. Thus, the orientation

stage supported by mathematics comics provided opportunities to develop mathematical communication ability from the beginning of the learning process.

The second stage involves organizing students for learning. At this stage, students worked collaboratively in groups to understand the problems presented in the student worksheets and mathematics comics. Through group discussions, they exchanged ideas, identified known and unknown information, and developed solution strategies. These interactions enabled students to express mathematical ideas in their own words, thereby improving their mathematical communication ability, particularly the written text indicator. In addition, group discussions encouraged students to express their opinions, appreciate others' ideas, and construct solutions collaboratively.

The third stage involves guiding individual and group investigations. During this phase, students collected information, discussed ideas, and developed solutions to the problems presented in the mathematics comics. Unlike the control group, which relied primarily on textbooks and worksheets, the experimental group benefited from visual illustrations and storylines that facilitated understanding of the problem context. These visual supports enabled students to relate information to the Pythagorean Theorem, represent mathematical ideas, and construct mathematical models more effectively. Furthermore, investigation and discussion activities encouraged students to exchange ideas and critically evaluate alternative solutions before reaching conclusions. Thus, integrating mathematics comics during the investigation stage contributed to the development of students' mathematical communication ability. This result is consistent with Peng et al. (2021), who found that visual design in multimedia learning enhances students' attention, cognitive engagement, and learning outcomes. Likewise, Chung and Cheon (2020) reported that incorporating images into instructional media increases learning motivation and facilitates understanding of instructional materials.

The fourth stage involves developing and presenting the results. During this stage, students organized and presented the solutions developed by their groups. Classroom presentations provided opportunities to explain their ideas, justify their problem-solving strategies, and respond to comments from other groups. Through these activities, students practiced communicating mathematical ideas clearly and logically in both oral and written forms, thereby strengthening their mathematical communication ability. In addition, the presentations increased students' confidence in expressing and defending their ideas.

The fifth stage involves analyzing and evaluating the problem-solving process. During this stage, students reflected on the learning process and the solutions they had developed with guidance from the teacher. Reflection enabled them to evaluate the accuracy of their solutions, identify and correct mistakes, and improve how they communicated mathematical ideas. Consequently, this stage further supported mathematical

communication ability by encouraging students to express, evaluate, and refine their reasoning systematically.

Although the control group also learned through the PBL model, mathematics comics were not incorporated into the instruction. Students relied on textbooks, worksheets, and teacher explanations to complete the learning activities. Although they followed the same PBL procedures, the predominance of text-based problems required greater effort to understand contextual situations and represent information mathematically. In contrast, students in the experimental group benefited from illustrated storylines that supported comprehension and mathematical representation. As a result, the control group's mathematical communication ability also improved, but the improvement was less substantial than that observed in the experimental group.

During the learning process in the experimental class, students appeared enthusiastic and actively participated in activities using mathematics comics. They engaged in discussions, expressed their ideas, and collaborated to solve the problems presented in the comics. During the first meeting, several challenges arose because some students were not yet accustomed to identifying problems and determining solutions based on the stories presented. In addition, the limited number of comics in each group prevented all students from using the medium optimally. To address these challenges, the teacher provided guidance and motivation to encourage more active participation and provided one comic for each student in the following meeting. This adjustment appeared to help students follow the content and participate more effectively in subsequent discussions.

Another challenge was that some students did not use rulers when constructing geometric figures, resulting in inaccurate drawings that affected the precision of their representations. This issue may have influenced their achievement on the drawing indicator of mathematical communication ability. To address it, the teacher asked students to compare figures drawn with and without rulers so that they could recognize the importance of accurate geometric representation. Several students were also initially reluctant to participate actively in group discussions because they lacked confidence in expressing their ideas. Consequently, the discussions were not fully effective. The teacher therefore continued to motivate students, encouraged every group member to contribute, and acknowledged each idea shared during discussions. As a result, students became more confident and participated more actively in subsequent learning activities.

Overall, the findings indicate that integrating mathematics comics into the PBL model provides greater opportunities to improve students' mathematical communication ability. Accordingly, this integration significantly affected the mathematical communication ability of eighth-grade students at SMP Negeri 4 Bandar Lampung during the second semester of the 2025/2026 academic year.

CONCLUSION AND RECOMMENDATION

Based on the results and discussion, integrating mathematics comics into the Problem-Based Learning (PBL) model had a significant effect on the mathematical communication ability of eighth-grade students at SMP Negeri 4 Bandar Lampung during the second semester of the 2025/2026 academic year. The median N-Gain score of students taught through the PBL model integrated with mathematics comics was significantly higher than that of students taught through the same model without mathematics comics. Thus, the experimental group demonstrated greater improvement in mathematical communication ability than the control group. Nevertheless, the study was limited to one mathematics topic. Teachers are therefore encouraged to use mathematics comics as an alternative instructional medium to enhance students' mathematical communication ability. They should also prepare media that meet students' learning needs, acknowledge students who actively present group discussion results, and ensure that students have the necessary learning materials and writing equipment. Future researchers are encouraged to develop mathematics comics that are better aligned with the characteristics of the learning material and students' needs to support a more effective and efficient learning process.

Artificial Intelligence Statement: The authors used ChatGPT (OpenAI) for grammar and style checking during manuscript preparation. All AI-assisted outputs were reviewed and revised by the authors, who remain fully responsible for the final content of the manuscript.

Author Contribution Statement: RM: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, Funding acquisition. N: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision. NS: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision.

Funding Statement: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest Statement: The authors declare no conflict of interest.

REFERENCES

Aji, W. P., & Mampouw, H. L. (2019). Pengembangan komik sebagai media pembelajaran matematika materi aljabar. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika (SENDIKA)*, *5*(1), 404–410. https://repository.uksw.edu/bitstream/123456789/19277/1/T1_202015039_Abstract.pdf

Amalia, A. P. E., & Nugraheni, N. (2024). Pengembangan komik berbasis problem based learning materi bangun datar untuk meningkatkan kemampuan komunikasi matematis siswa. *Jurnal Muara Pendidikan*, *9*(2), 308–315. https://doi.org/10.52060/mp.v9i2.2384

Apostolou, D., & Linardatos, G. (2023). Cognitive load approach to digital comics creation: A student-centered learning case. *Applied Sciences*, *13*(13), Article 7896. https://doi.org/10.3390/app13137896

Arends, R. I. (2012). *Learning to teach* (9th ed.). McGraw-Hill. https://books.google.com/books?id=B1trewAACAAJ

Badan Standar, Kurikulum, dan Asesmen Pendidikan. (2024). *Keputusan Kepala Badan Standar, Kurikulum, dan Asesmen Pendidikan Nomor 032/H/KR/2024 tentang capaian pembelajaran pada pendidikan anak usia dini, jenjang pendidikan dasar, dan jenjang pendidikan menengah pada Kurikulum Merdeka*. https://bbgtksumut.kemendikdasmen.go.id/portal/keputusankepala-badan-standar-kurikulum-dan-asesmen-pendidikankementerian-pendidikan-kebudayaan-riset-dan-teknologinomor-032-h-kr-2024/

Chung, S., & Cheon, J. (2020). Emotional design of multimedia learning using background images with motivational cues. *Journal of Computer Assisted Learning*, *36*(6), 922–932. https://doi.org/10.1111/jcal.12450

Cohn, N. (2013). Visual narrative structure. *Cognitive Science*, *37*(3), 413–452. https://doi.org/10.1111/cogs.12016

Corebima, M. A. Y., Garak, S. S., & Samo, D. D. (2020). Pengaruh problem based learning terhadap kemampuan komunikasi matematis siswa pada materi program linear. *RANGE: Jurnal Pendidikan Matematika*, *2*(1), 56–65. https://doi.org/10.32938/jpm.v2i1.569

Fadella, E. F., & Prabowo, A. (2018). Keefektifan problem-based learning berbantuan komik matematika terhadap kemampuan pemecahan masalah dan rasa ingin tahu siswa. *PRISMA, Prosiding Seminar Nasional Matematika*, *1*, 77–86. https://www.researchgate.net/publication/343636053_Keefektifan_Problem-Based_Learning_Berbantuan_Komik_Matematika_terhadap_Kemampuan_Pemecahan_Masalah_dan_Rasa_Ingin_Tahu_Siswa

Fikriani, T., & Nurva, M. S. (2020). Pengembangan bahan ajar matematika berbentuk komik untuk meningkatkan kemampuan matematis siswa kelas VII SMP. *JARTIKA: Jurnal Riset Teknologi dan Inovasi Pendidikan*, *3*(1), 11–24. https://doi.org/10.36765/jartika.v3i1.25

Hafriani, H. (2021). Mengembangkan kemampuan dasar matematika siswa berdasarkan NCTM melalui tugas terstruktur dengan menggunakan ICT. *Jurnal Ilmiah Didaktika*, *22*(1), 63–80. https://doi.org/10.22373/jid.v22i1.7974

Hodiyanto. (2017). Kemampuan komunikasi matematis dalam pembelajaran matematika. *AdMathEdu*, *7*(1), 9–18. https://doi.org/10.12928/admathedu.v7i1.7397

Jazuli, S. A., Syafmen, W., & Falani, I. (2024). Pengembangan media pembelajaran berbentuk komik matematika menggunakan model problem based learning (PBL) untuk meningkatkan kemampuan komunikasi matematis siswa SMP. *Jurnal Ilmiah Matematika Realistik*, *5*(2), 221–232. https://doi.org/10.33365/ji-mr.v5i2.5263

Layliyyah, R., Wisudaningsih, E. T., & Rahayu, E. (2022). Pengaruh model pembelajaran problem based learning terhadap kemampuan komunikasi matematis siswa kelas VII. *Jurnal Pendidikan dan Konseling (JPDK)*, *4*(4), 345–351. https://doi.org/10.31004/jpdk.v4i4.5231

Lubis, R. N., Meiliasari, & Rahayu, W. (2023). Kemampuan komunikasi matematis siswa pada pembelajaran matematika. *Jurnal Riset Pembelajaran Matematika Sekolah*, *7*(2), 23–34. https://doi.org/10.21009/jrpms.072.03

Marlina, L., Yumiati, Y., & Novianti, I. (2023). Pengembangan bahan pembelajaran berbasis problem based learning (PBL) dengan media komik untuk meningkatkan kemampuan komunikasi dan berpikir kritis matematis siswa SMP. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *7*(3), 3093–3108. https://doi.org/10.31004/cendekia.v7i3.2157

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. https://www.nctm.org/standards/

Novitasari, L. L. A., Suryanti, S., & Dwikoraingsih, D. (2024). Upaya peningkatan kemampuan komunikasi matematis tulis dan lisan peserta didik melalui model pembelajaran problem based learning (PBL) dengan pendekatan pembelajaran berdiferensiasi metode diskusi. *Proceeding International Conference on Lesson Study*, *1*(1), 485–501. https://doi.org/10.30587/icls.v1i1.7397

Nurhanurawati, N., Suryadinata, N., & Mutmainah, S. (2026). Comparative effects of problem-based learning, creative problem solving, and problem posing on junior high school students' mathematical reasoning. *Jurnal Pendidikan MIPA*, *27*(1), 383–396. https://doi.org/10.23960/jpmipa.v27i1.pp383-396

Peng, X., Xu, Q., Chen, Y., Zhou, C., Ge, Y., & Li, N. (2021). An eye tracking study: Positive emotional interface design facilitates learning outcomes in multimedia learning? *International Journal of Educational Technology in Higher Education*, *18*, Article 40. https://doi.org/10.1186/s41239-021-00274-x

Pemerintah Republik Indonesia. (2022). *Peraturan Pemerintah Republik Indonesia Nomor 4 Tahun 2022 tentang perubahan atas Peraturan Pemerintah Nomor 57 Tahun 2021 tentang Standar Nasional Pendidikan*. https://peraturan.bpk.go.id/Home/Details/196151

Purnamasari, A., & Afriansyah, E. A. (2021). Kemampuan komunikasi matematis siswa SMP pada topik penyajian data di pondok pesantren. *Plusminus: Jurnal Pendidikan Matematika*, *1*(2), 207–222. https://journal.institutpendidikan.ac.id/index.php/plusminus/article/view/896

Rista, L., Eviyanti, C. Y., & Hadijah, S. (2019). Peningkatan kemampuan representasi matematis dan self-confidence siswa melalui pembelajaran humanistik berbasis pendidikan matematika realistik. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *3*(2), 525–535. https://doi.org/10.31004/cendekia.v3i2.141

Robbani, A. S., & Khoirotunnisa, U. (2021). Online English comics as reading materials for English language education department students. *European Journal of Educational Research*, *10*(3), 1359–1369. https://doi.org/10.12973/eu-jer.10.3.1359

Saputro, A. D. (2016). Aplikasi komik sebagai media pembelajaran. *Muaddib: Studi Kependidikan dan Keislaman*, *5*(1), 1–19. https://doi.org/10.24269/muaddib.v5i1.101

Sholehah, M. A., Wisudaningsih, E. T., & Lestari, W. (2022). Analisis kesulitan siswa SMA dalam menyelesaikan soal asesmen kompetensi minimum numerasi berdasarkan teori Polya. *Jurnal Pendidikan dan Konseling (JPDK)*, *4*(4), 65–73. https://doi.org/10.31004/jpdk.v4i4.5163

Sinaga, R. S., & Manik, S. C. (2019). Pengaruh model pembelajaran problem based learning terhadap kemampuan komunikasi matematis siswa kelas VIII SMP Negeri 2 Salapian Kabupaten Langkat tahun pelajaran 2018/2019. *Jurnal Serunai Ilmu Pendidikan*, *5*(1), 53–58. https://doi.org/10.37755/sjip.v5i1.154

Subroto, E. N., Qohar, A., & Dwiyana. (2020). Efektivitas pemanfaatan komik sebagai media pembelajaran matematika. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *5*(2), 135–141. https://doi.org/10.17977/jptpp.v5i2.13156

Suwanti, S., & Maryati, I. (2021). Kemampuan representasi matematis siswa melalui model problem based learning dan probing prompting learning. *Plusminus: Jurnal Pendidikan Matematika*, *1*(2), 303–314. https://doi.org/10.31980/plusminus.v1i2.1263

Tavares, R., Alemany-Pagès, M., Araújo, S., Cohn, N., Ramalho-Santos, J., & Azul, A. M. (2023). Comics in science and health communication: Insights from mutual collaboration and framing a research practice. *International Journal of Qualitative Methods*, *22*, Article 16094069231183118. https://doi.org/10.1177/16094069231183118

Warsono, & Hariyanto. (2012). *Pembelajaran aktif dan asesmen*. Remaja Rosdakarya. https://books.google.com/books?q=Warsono+Hariyanto+Pembelajaran+Aktif+dan+Asesmen

Widiasworo, E. (2018). *Strategi pembelajaran edutainment berbasis karakter*. Ar-Ruzz Media. https://balaiyanpus.jogjaprov.go.id/opac/detail-opac?id=313738

Yusuf, R. M. M., & Ratnaningsih, N. (2022). Analisis kesalahan numerasi peserta didik dalam menyelesaikan soal asesmen kompetensi minimum. *Jurnal Paedagogy*, *9*(1), 24–33. https://doi.org/10.33394/jp.v9i1.4507