MIKAILALSYS
Journal of Multidisciplinary Sciences

e-ISSN : 2987-2286
p-ISSN : 2987-3924

Index: Harvard, Boston, Sydney, Copernicus, Sinta 4, Scilit, Semantic, Google, etc

https://doi.org/10.58578/mikailalsys.v4i3.11588

The Effect of the Problem-Based Learning Model Assisted by Assemblr Edu on the Mathematics Learning Outcomes of Students at SMP Negeri 2 Kabuh

Amiliya Hanim Nur Faidah & Oemi Noer Qomariyah
Universitas PGRI Jombang, Indonesia
amiliyahanimnur@gmail.com; umi.stkipjb@gmail.com

Article Info:

Submitted:	Revised:	Accepted:	Published:
Jun 16, 2026	Jul 14, 2026	Jul 26, 2026	Jul 31, 2026

Abstract

Low student achievement in three-dimensional geometry indicates the need for innovative instructional approaches that promote active participation and facilitate the visualization of abstract mathematical concepts. This study aimed to examine the effect of the Problem-Based Learning (PBL) model assisted by Assemblr Edu on the mathematics learning outcomes of students at SMP Negeri 2 Kabuh. A quantitative quasi-experimental approach with a nonequivalent posttest-only control group design was employed. Participants were selected through purposive sampling and comprised 64 ninth-grade students, with 32 students in the experimental class (IX-D) and 32 students in the control class (IX-C). Data were collected using a validated essay-based mathematics achievement test and analyzed through normality, homogeneity, and Mann–Whitney U tests using IBM SPSS Statistics version 27. The findings showed that the experimental group achieved a higher mean posttest score than the control group (88.68 vs. 74.84). The Mann–Whitney U test yielded p = .001, indicating a statistically significant difference in mathematics learning outcomes between the two groups. These findings demonstrate that PBL assisted by Assemblr Edu

effectively supports students' achievement in three-dimensional geometry by integrating problem-oriented learning with augmented reality-based visualization. This study contributes practical evidence that combining PBL with Assemblr Edu offers an effective technology-enhanced instructional alternative for improving mathematics learning outcomes at the junior secondary school level.

Keywords: Assemblr Edu; Augmented Reality; Mathematics Learning Outcomes; Problem-Based Learning; Three-Dimensional Geometry

INTRODUCTION

Education plays a fundamental role in developing human resources capable of responding to rapid technological advancement and increasingly complex societal challenges. To improve educational quality, Indonesia has implemented the Merdeka Curriculum, which emphasizes flexible, student-centered learning and encourages teachers to design instructional activities that accommodate students' characteristics and contextual learning needs (Telaumbanua et al., 2025). The curriculum reflects a broader educational transformation that promotes active participation, creativity, and independent learning rather than conventional knowledge transmission (Indarta et al., 2022).

Within this educational framework, mathematics occupies a strategic position because it equips students with logical reasoning, analytical thinking, and problem-solving abilities that are essential for lifelong learning. Nevertheless, mathematics remains one of the most challenging subjects for many junior high school students due to its abstract concepts and the predominance of teacher-centered instructional practices (Azizah & Wardani, 2024). These conditions often reduce students' learning motivation and limit their conceptual understanding, ultimately affecting their academic achievement (Astari et al., 2025).

International evidence further highlights the urgency of improving mathematics education. The Programme for International Student Assessment (PISA) 2022 reported that only a relatively small proportion of Indonesian students achieved the minimum proficiency level in mathematical literacy, indicating that many students continue to experience difficulties in applying mathematical concepts to authentic situations (OECD, 2022). Similar findings demonstrate that students' mathematics achievement is closely associated with the quality of instructional strategies implemented in the classroom (Joshi et al., 2025).

To address these challenges, mathematics instruction requires learning approaches that actively engage students in constructing knowledge rather than passively receiving information. Contemporary educational paradigms advocate learning environments where students investigate authentic problems, collaborate with peers, and develop higher-order thinking skills through meaningful learning experiences (Fauzi et al., 2023). Such approaches are expected to strengthen conceptual understanding while simultaneously improving students' engagement during classroom activities (Hadi et al., 2025).

Problem-Based Learning (PBL) has been widely recognized as one of the instructional models capable of facilitating these objectives. Rather than emphasizing memorization, PBL encourages students to analyze contextual problems, formulate hypotheses, gather relevant information, and propose evidence-based solutions through collaborative inquiry (Smith et al., 2022). This learning process positions teachers as facilitators while allowing students to become active participants in knowledge construction (Endayani, 2023).

Numerous empirical studies have confirmed the effectiveness of PBL in improving mathematics learning outcomes. Previous research demonstrated that the implementation of PBL significantly enhanced students' academic achievement across different educational contexts by promoting critical thinking and active participation during classroom learning (Cahyandani, 2022). Likewise, Nugraha (2023) reported that students taught through the PBL model achieved higher mathematics learning outcomes than those receiving conventional instruction.

Beyond academic achievement, PBL also contributes to the development of collaborative learning and critical thinking skills that are increasingly demanded in twenty-first-century education. Research indicates that students participating in PBL demonstrate stronger collaboration, communication, and analytical reasoning throughout the learning process (Nova et al., 2024). Furthermore, integrating PBL with innovative instructional approaches has been shown to strengthen students' independent learning and argumentation skills, thereby creating more meaningful learning experiences (Kurniawati et al., 2025).

Despite the considerable benefits of PBL, the successful implementation of this model also depends on the availability of instructional media capable of visualizing abstract mathematical concepts. This issue is particularly important in geometry learning because students frequently encounter difficulties when interpreting three-dimensional objects

through conventional two-dimensional representations (Mulyatna et al., 2023). Consequently, the integration of digital learning technologies has become increasingly relevant in mathematics education as an effective strategy for enhancing conceptual understanding (Engelbrecht & Borba, 2024).

The integration of digital technology into mathematics education has become increasingly important because it enables students to interact with abstract concepts through more concrete and engaging learning experiences. Recent developments in educational technology suggest that digital learning environments not only improve students' conceptual understanding but also foster motivation and active participation during classroom instruction (Saat et al., 2024). Likewise, the effective use of digital technology has been identified as an essential component of contemporary mathematics education that supports meaningful learning and higher student achievement (Engelbrecht & Borba, 2024).

One instructional technology that has attracted growing attention is Assemblr Edu, an Augmented Reality (AR)-based learning application that enables students to observe and manipulate three-dimensional mathematical objects interactively. Through realistic visualization, students can explore geometric concepts from multiple perspectives, making abstract ideas easier to comprehend (Mukaromah, 2025). This technology is particularly appropriate for learning solid geometry because it provides direct visual experiences that are difficult to achieve through conventional instructional media (Chairudin et al., 2023).

Previous studies consistently demonstrate the educational benefits of Assemblr Edu in mathematics learning. AR-based learning media have been found to improve students' mathematical problem-solving abilities while simultaneously increasing learning engagement (Fadilasari & Nugraheni, 2025). Similarly, Assemblr Edu has proven effective in enhancing elementary students' learning outcomes by providing interactive learning experiences that encourage deeper conceptual understanding (Nafi'ah & Asih, 2024).

Other empirical evidence further confirms that AR technology positively influences students' understanding of geometry concepts by improving spatial visualization and classroom interaction (Rohendi et al., 2025). Research also indicates that students who learn through Assemblr Edu demonstrate greater motivation because the learning process becomes more interactive, enjoyable, and visually meaningful (Khairunisa et al., 2024).

The effectiveness of Assemblr Edu has also been reported in studies conducted at different educational levels. Afia (2024) found that AR-based Assemblr Edu significantly

improved students' numeracy literacy when learning three-dimensional geometry. Likewise, Oktavia (2024) concluded that Assemblr Edu contributed positively to students' conceptual understanding of solid geometry by facilitating visual exploration of mathematical objects.

Several researchers have attempted to combine innovative instructional models with digital media to maximize mathematics learning outcomes. Putri et al. (2024) reported that integrating Problem-Based Learning with interactive learning media produced higher mathematics achievement than conventional instruction. Similarly, Simamora et al. (2023) demonstrated that contextual problem-solving activities strengthened students' mathematical literacy by encouraging them to construct knowledge collaboratively.

Although previous studies have independently confirmed the effectiveness of Problem-Based Learning and Assemblr Edu, most investigations have examined these instructional components separately or within different educational contexts. Existing studies have predominantly focused on conceptual understanding, numeracy literacy, or problem-solving skills rather than students' mathematics learning outcomes under the implementation of the Merdeka Curriculum in junior high schools. Moreover, empirical evidence specifically examining the combined implementation of Problem-Based Learning supported by Assemblr Edu for Grade IX students learning solid geometry remains relatively limited (Ningsih, 2025).

Research Gap. Based on the existing literature, a clear research gap can be identified. Previous studies have primarily evaluated either the instructional effectiveness of Problem-Based Learning or the educational potential of Assemblr Edu independently. Limited attention has been devoted to investigating how the integration of these two instructional innovations influences mathematics learning outcomes among junior high school students, particularly within the context of the Merdeka Curriculum and the topic of three-dimensional geometry. This gap indicates the need for empirical evidence that simultaneously examines the pedagogical contribution of an active learning model and immersive digital technology in improving students' cognitive achievement.

Novelty. The novelty of this study lies in integrating Problem-Based Learning with Assemblr Edu as an Augmented Reality learning medium to improve mathematics learning outcomes among Grade IX students studying solid geometry. Unlike previous research that mainly emphasized conceptual understanding or numeracy literacy, this study specifically evaluates students' cognitive learning outcomes through a quasi-experimental design

implemented in the Merdeka Curriculum context. This integrated instructional approach provides a more comprehensive perspective on how active learning strategies and immersive digital visualization can complement one another to enhance mathematics learning effectiveness.

The theoretical foundation of this research is built upon the constructivist perspective underlying Problem-Based Learning, which emphasizes that knowledge is actively constructed through authentic problem-solving experiences and collaborative inquiry (Smith et al., 2022). In addition, the instructional use of Augmented Reality is grounded in the theory that interactive visualization facilitates students' cognitive processing of abstract mathematical concepts, thereby supporting deeper conceptual understanding and meaningful learning experiences (Doz et al., 2025).

Accordingly, this study aims to examine the effect of implementing the Problem-Based Learning model assisted by Assemblr Edu on the mathematics learning outcomes of Grade IX students at SMP Negeri 2 Kabuh. The findings are expected to contribute empirical evidence regarding the effectiveness of integrating active learning pedagogy with Augmented Reality technology while providing practical recommendations for mathematics teachers seeking innovative instructional strategies that align with the objectives of the Merdeka Curriculum.

METHODS

This study employed a quantitative approach using a quasi-experimental design to investigate the effect of the Problem-Based Learning (PBL) model assisted by Assemblr Edu on students' mathematics learning outcomes. The study adopted a Nonequivalent Posttest-Only Control Group Design, involving an experimental group that received PBL assisted by Assemblr Edu and a control group that was taught using the conventional lecture method. At the end of the learning process, both groups completed a posttest to measure their mathematics learning outcomes. The population consisted of all ninth-grade students of SMP Negeri 2 Kabuh in the 2025/2026 academic year. Purposive sampling was employed based on the mathematics teacher's recommendation, considering the comparable academic characteristics of the students. Consequently, Class IX-D was selected as the experimental group, while Class IX-C served as the control group. The independent variable was the

implementation of the PBL model assisted by Assemblr Edu, whereas the dependent variable was students' mathematics learning outcomes.

Data were collected using a posttest consisting of five essay questions. Prior to data collection, the instrument was validated through content validity by two experts, namely a Mathematics Education lecturer from Universitas PGRI Jombang and a mathematics teacher from SMP Negeri 2 Kabuh. Revisions were made based on the validators' recommendations before the instrument was administered to both groups. Students' responses were then scored according to the established scoring guidelines. The data were analyzed using IBM SPSS Statistics version 27. Descriptive statistics were followed by the Shapiro–Wilk normality test and the homogeneity of variance test as prerequisite analyses. If the assumptions of normality and homogeneity were satisfied, an Independent Samples t-test was performed to compare the mathematics learning outcomes between the two groups. Otherwise, the Mann–Whitney U test was applied as the non-parametric alternative. Statistical significance was determined at the 0.05 level.

RESULTS

1. Normality Test

Table 1. Normality Test Results for the Control Group

Tests of Normality			
	Shapiro-Wilk		
	Statistic	df	Sig.
Posttest Control Group	.916	32	.016
a. Lilliefors Significance Correction			

source: Compiled by the researcher (2026)

Table 1. Normality Test Results for the Control Group shows that the Shapiro–Wilk significance value for the control group was 0.016, which is lower than the significance level of 0.05. Therefore, the posttest scores of the control group were not normally distributed.

Table 2. Normality Test Results for the Experimental Group

Tests of Normality			
	Shapiro-Wilk		
	Statistic	df	Sig.
Posttest Experimental Group	.920	32	.021
**. This is a lower bound of the true significance.*			
a. Lilliefors Significance Correction			

Table 2. Normality Test Results for the Experimental Group shows that the Shapiro–Wilk significance value for the experimental group was 0.021, which is also lower than 0.05. Thus, the posttest scores of the experimental group were not normally distributed.

2. Homogeneity Test

Table 3. Homogeneity Test Results

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Nilai Posttest	Based on Mean	1.157	1	62	.286
	Based on Median	.729	1	62	.397
	Based on Median and with adjusted df	.729	1	55.721	.397
	Based on trimmed mean	1.105	1	62	.297

source: Compiled by the researcher (2026)

Table 3. Homogeneity Test Results shows that the significance value based on the mean was 0.286, which is greater than 0.05. Therefore, the variances of the control and experimental groups were homogeneous, indicating that both groups had equal variances.

4. Hypothesis Testing (Mann–Whitney U Test)

Mann-Whitney Test

Ranks

	Group	N	Mean Rank	Sum of Ranks
Mathematics Learning Outcomes Posttest	Experimental Group (PBL assisted by Assemblr Edu)	32	44.14	1412.50
	Control Group (Conventional Method)	32	20.86	667.50
	Total	64		

Test Statistics[a]

	Mathematics Learning Outcomes (Posttest)
Mann-Whitney U	139.500
Z	-5.008
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Learning Model

Figure 1. Mann–Whitney U Test Results

Figure 1. Mann–Whitney U Test Results shows that the Asymp. Sig. (2-tailed) value was 0.001, which is lower than the significance level of 0.05. Therefore, the null hypothesis (H_0) was rejected, indicating a statistically significant difference in mathematics learning

outcomes between students taught using the Problem-Based Learning (PBL) model assisted by Assemblr Edu and those taught using conventional instruction. These findings indicate that the PBL model assisted by Assemblr Edu had a significant effect on students' mathematics learning outcomes.

DISCUSSION

The findings of this study demonstrate that implementing the Problem-Based Learning (PBL) model assisted by Assemblr Edu significantly improved students' mathematics learning outcomes compared with conventional lecture-based instruction. The experimental group achieved a mean posttest score of 88.68, whereas the control group obtained a mean score of 74.84. Moreover, the Mann–Whitney U test yielded a significance value of 0.001 ($p < .05$), indicating a statistically significant difference between the two groups. These findings suggest that integrating Problem-Based Learning with Augmented Reality-based learning media provides a more effective instructional approach for improving students' achievement in learning three-dimensional geometry.

The superiority of the experimental group can be interpreted from the instructional characteristics of Problem-Based Learning. Rather than positioning students as passive recipients of information, PBL encourages them to identify problems, formulate possible solutions, collaborate with peers, and evaluate alternative approaches. Such learning experiences promote active knowledge construction and meaningful conceptual understanding. During these activities, students are required to connect prior knowledge with newly acquired information, enabling them to develop stronger conceptual foundations and improve their mathematical reasoning. Consequently, learning outcomes are enhanced because students understand not only procedural steps but also the underlying mathematical concepts.

The use of Assemblr Edu further strengthened the effectiveness of the learning process by transforming abstract geometric concepts into interactive three-dimensional visualizations. Solid geometry is widely recognized as one of the mathematical topics that students often find difficult because conventional two-dimensional illustrations cannot adequately represent three-dimensional objects. Assemblr Edu addresses this challenge by allowing students to observe, manipulate, and explore geometric objects from multiple perspectives, thereby facilitating deeper conceptual understanding. This interactive

visualization reduced students' cognitive difficulties and increased their engagement throughout the learning activities, contributing to the higher achievement observed in the experimental group.

The present findings are consistent with previous studies demonstrating the educational benefits of Problem-Based Learning. Sagita (2023) reported that PBL significantly improved mathematics learning outcomes among junior high school students because it promoted active participation and critical thinking throughout the instructional process. Likewise, Nugraha (2023) found that students taught using the Problem-Based Learning model achieved higher academic performance than those receiving conventional instruction. These studies support the present findings by confirming that learner-centered instructional strategies provide greater opportunities for students to construct mathematical understanding independently.

The findings also corroborate previous research on the educational effectiveness of Assemblr Edu. Afia (2024) concluded that Augmented Reality-based Assemblr Edu effectively enhanced students' numeracy literacy in geometry learning. Similarly, Ningsih (2025) reported that integrating Problem-Based Learning with Assemblr Edu positively influenced students' conceptual understanding of mathematics. The consistency between these studies and the present research indicates that the combination of an active learning model and immersive digital technology creates a learning environment that supports both conceptual understanding and academic achievement.

Although previous studies have primarily examined conceptual understanding or numeracy literacy, this study extends the existing literature by demonstrating that the integration of Problem-Based Learning and Assemblr Edu also contributes significantly to students' mathematics learning outcomes at the junior high school level. This finding provides additional empirical evidence that instructional innovation should not rely solely on pedagogical models or digital media independently; instead, their combined implementation can produce greater educational benefits by simultaneously promoting active learning, visualization, collaboration, and problem-solving.

Beyond confirming the effectiveness of the instructional intervention, this study offers several important theoretical and practical implications. From a theoretical perspective, the findings reinforce the constructivist principles underlying Problem-Based Learning, which emphasize that meaningful knowledge is actively constructed through

authentic problem-solving experiences rather than passive information transmission. The results also support the growing body of literature suggesting that digital technologies, particularly Augmented Reality, enhance mathematics learning by providing visual representations that facilitate conceptual understanding and cognitive engagement. Consequently, this study strengthens the theoretical argument that integrating active learning strategies with technology-enhanced instruction creates more meaningful mathematics learning experiences.

From a practical perspective, the findings provide valuable guidance for mathematics teachers implementing the Merdeka Curriculum. Teachers may consider integrating Problem-Based Learning with Assemblr Edu, particularly when teaching abstract topics such as three-dimensional geometry. The visualization features offered by Assemblr Edu enable students to explore mathematical objects interactively, while the collaborative nature of Problem-Based Learning encourages communication, critical thinking, and independent learning. As a result, classroom instruction becomes more engaging and student-centered, which ultimately contributes to improved learning outcomes. These findings also suggest that schools should support teachers by providing adequate technological facilities and professional development related to innovative digital learning strategies.

Methodologically, this study demonstrates that a quasi-experimental design using a Nonequivalent Posttest-Only Control Group Design provides an appropriate framework for evaluating instructional effectiveness in authentic school settings where random assignment is impractical. The application of the Mann–Whitney U test also ensured that statistical conclusions remained valid despite the violation of the normality assumption identified during the preliminary analysis.

Despite these contributions, several limitations should be acknowledged. First, the study involved participants from only one junior high school, which may limit the generalizability of the findings to different educational contexts. Second, the research focused exclusively on the topic of three-dimensional geometry; therefore, the effectiveness of the instructional model for other mathematics topics remains uncertain. Third, students' learning outcomes were measured using a posttest consisting of essay questions, emphasizing cognitive achievement without examining other learning dimensions such as motivation, attitudes, or long-term knowledge retention. Finally, the sampling procedure employed

purposive sampling based on teachers' recommendations rather than random assignment, which is a common limitation of quasi-experimental research.

Future studies are encouraged to investigate the effectiveness of Problem-Based Learning assisted by Assemblr Edu across broader educational settings, different mathematics topics, and larger samples. Researchers may also incorporate additional variables, such as mathematical reasoning, problem-solving ability, learning motivation, or digital literacy, to obtain a more comprehensive understanding of the instructional model's educational impact.

Overall, this study contributes to the growing literature on innovative mathematics instruction by providing empirical evidence that the integration of Problem-Based Learning and Assemblr Edu significantly improves students' mathematics learning outcomes. Unlike previous studies that primarily examined either the learning model or the digital medium separately, this research demonstrates the educational value of combining both instructional innovations within the context of the Merdeka Curriculum. Accordingly, the study offers both theoretical support for constructivist learning and practical recommendations for teachers seeking effective strategies to improve mathematics achievement in secondary education.

CONCLUSION

This study demonstrates that the implementation of the Problem-Based Learning (PBL) model assisted by Assemblr Edu has a positive and statistically significant effect on students' mathematics learning outcomes in the topic of three-dimensional geometry. Students who participated in learning activities supported by Problem-Based Learning and Assemblr Edu achieved higher learning outcomes than those who received conventional lecture-based instruction. These findings confirm that the research objective, namely to examine the effect of the PBL model assisted by Assemblr Edu on students' mathematics achievement, has been successfully achieved. The integration of problem-based instruction with Augmented Reality technology created a more engaging, interactive, and student-centered learning environment that facilitated students' understanding of abstract mathematical concepts.

This study contributes to mathematics education by providing additional empirical evidence that combining innovative pedagogical approaches with digital learning

technologies can improve both the quality of classroom instruction and students' academic achievement. The findings reinforce the educational value of Problem-Based Learning while highlighting the potential of Assemblr Edu as an effective instructional medium for visualizing geometric concepts. Consequently, the study offers practical support for implementing technology-enhanced learning strategies within the context of the Merdeka Curriculum.

The findings also have important practical implications for mathematics teachers and schools. Teachers are encouraged to integrate Problem-Based Learning supported by Assemblr Edu to promote active learning, strengthen conceptual understanding, and improve students' learning outcomes. Educational institutions should facilitate the implementation of innovative digital learning by providing adequate technological resources and professional development opportunities for teachers. Future research is recommended to examine the effectiveness of this instructional approach across different mathematics topics, educational levels, and broader populations, while also investigating its influence on other educational outcomes, including problem-solving ability, critical thinking, learning motivation, and mathematical literacy. Such studies would provide a more comprehensive understanding of the educational potential of integrating Problem-Based Learning with Augmented Reality-based learning media.

REFERENCES

Afia, A. N. (2024). *Efektivitas Penggunaan Media Assemblr Edu Berbasis Augmented Reality terhadap Peningkatan Kemampuan Literasi Numerasi Siswa pada Materi Bangun Ruang* [Undergraduate thesis, Universitas Islam Sultan Agung Semarang]. https://repository.unissula.ac.id/id/eprint/37295

Astari, D. J., Hutabarat, E. M., Tampubolon, D. H., Panjaitan, D. N., & Lubis, N. S. A. (2025). Hubungan antara Faktor-Faktor yang Mempengaruhi Hasil Belajar Siswa Kelas 9 di SMPN 27 Medan. *Jurnal Pendidikan Tambusai, 9*(1), 11293–11299. https://jptam.org/index.php/jptam/article/view/26488

Azizah, N., & Wardani, H. (2024). Analisis Pembelajaran Matematika dengan Mengimplementasikan Kurikulum Merdeka. *Jurnal Cendekia: Jurnal Pendidikan Matematika, 8*(1), 222–233. https://doi.org/10.31004/cendekia.v8i1.3061

Cahyandani, N. (2022). Implementation of the problem-based learning model to improve the learning outcomes of class IV students of Jatisobo 4 Elementary School. *Social, Humanities, and Education Studies (SHEs): Conference Series, 5*(5), 20–27. https://jurnal.uns.ac.id/SHES/article/view/77979

Chairudin, M., Nurhanifa, Yustianingsih, T., Aidah, Z., & Atoillah. (2023). Studi Literatur Pemanfaatan Aplikasi Assemblr Edu sebagai Media Pembelajaran Matematika Jenjang SMP/MTs. *Community Development Journal: Jurnal Pengabdian Masyarakat, 4*(2),

1312–1318. https://journal.universitaspahlawan.ac.id/index.php/cdj/article/view/12881

Doz, D., Žakelj, A., & Cotič, M. (2025). Inquiry-based learning in Grade 9 mathematics: Assessing outcomes across Gagné's taxonomy. *Educational Studies in Mathematics, 120*(2), 269–298. https://doi.org/10.1007/s10649-025-10417-w

Endayani, H. (2023). *Bahan Ajar Pembelajaran Berbasis Masalah*.

Engelbrecht, J., & Borba, M. C. (2024). Recent developments in using digital technology in mathematics education. *ZDM–Mathematics Education, 56*(2), 281–292. https://doi.org/10.1007/s11858-023-01530-2

Fadilasari, E., & Nugraheni, N. (2025). Development of Assemblr Edu learning media based on augmented reality to improve elementary school students' mathematics problem-solving ability. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran, 11*(1), 248–258. https://doi.org/10.33394/jk.v11i1.14831

Fauzi, M. A. R., Azizah, S. A., & Atikah, I. (2023). Pembelajaran Berdiferensiasi sebagai Implementasi Paradigma Baru Pendidikan. *Jurnal Teknologi Pendidikan, 1*(1), Article 10. https://doi.org/10.47134/jtp.v1i1.38

Hadi, A. I. M., Pahrudin, A., Jatmiko, A., & Koderi. (2025). Pengaruh Kurikulum Merdeka dalam Pembelajaran: Sebuah Kajian Literatur. *LEARNING: Jurnal Inovasi Penelitian Pendidikan dan Pembelajaran, 5*(1), 360–372. https://doi.org/10.51878/learning.v5i1.4523

Joshi, D. R., Sharma Chapai, K. P., Upadhayaya, P. R., Adhikari, K. P., & Belbase, S. (2025). Effect of using digital resources on mathematics achievement: Results from PISA 2022. *Cogent Education, 12*(1), Article 2488161. https://doi.org/10.1080/2331186X.2025.2488161

Khairunisa, W., Taufik, A. N., & Pamungkas, T. A. (2024). Pengembangan Augmented Reality Berbantuan Assemblr Edu dalam Menumbuhkan Motivasi Belajar Siswa SMP Kelas VIII. *Jurnal Pendidikan MIPA, 14*(4), 1177–1185. https://doi.org/10.37630/jpm.v14i4.2198

Kurniawati, I. L., Setyosari, P., Dasna, I. W., & Praherdhiono, H. (2025). Integrating PBL and flipped classroom to enhance students' argumentation and self-directed learning. *JPBI (Jurnal Pendidikan Biologi Indonesia), 11*(1), 360–369. https://doi.org/10.22219/jpbi.v11i1.37430

Mukaromah, D. S. (2025). *Pengembangan Media Pembelajaran Matematika Berbasis Augmented Reality Menggunakan Assemblr Edu untuk Meningkatkan Kemampuan Pemahaman Matematis pada Materi Bangun Ruang Sisi Lengkung Kelas IX* [Undergraduate thesis, UIN Prof. K.H. Saifuddin Zuhri]. http://repository.uinsaizu.ac.id/id/eprint/30260

Mulyatna, F., Jinan, A. Z., Amalina, C. N., Widyawati, E. P., Aprilita, G. A., & Suhendri, H. (2023). Deskripsi Pemahaman Konsep Matematika pada Materi Bangun Ruang Menggunakan Metode Diskusi Kelompok. *Transformasi: Jurnal Pendidikan Matematika dan Matematika, 7*(1), 107–118. https://doi.org/10.36526/tr.v7i1.2854

Nafi'ah, Z., & Asih, S. S. (2024). Assemblr Edu learning media based on augmented reality to improve learning outcomes of Grade V elementary school students. *Jurnal Penelitian Pendidikan IPA, 10*(11), 8918–8926. https://doi.org/10.29303/jppipa.v10i11.9544

Ningsih, S. (2025). *Pengaruh Model Pembelajaran Problem Based Learning Berbantuan Media Aplikasi Assemblr Edu terhadap Pemahaman Konsep Matematika Kelas IV di SD Negeri 1 Harapan Jaya Bandar Lampung* [Undergraduate thesis, UIN Raden Intan Lampung]. https://repository.radenintan.ac.id/id/eprint/36991

Nova, F., Listyono, & Mirtaati, N. (2024). The influence of problem-based learning (PBL) on critical and collaborative thinking skills in integrated biology learning with Islamic values. *Al-Alam: Islamic Natural Science Education Journal, 3*(2), 52–68. https://doi.org/10.33477/al-alam.v3i2.7397

Nugraha, A. (2023). Pengaruh Model Problem Based Learning dan Gaya Belajar terhadap Prestasi Belajar. *DIADIK: Jurnal Ilmiah Teknologi Pendidikan, 13*(2), 467–481. https://doi.org/10.33369/diadik.v13i2.31562

OECD. (2023). *PISA 2022 Results*. https://www.oecd.org/publication/pisa-2022-results/

Octavia, D. (2024). *Pengaruh Assemblr Edu terhadap Kemampuan Pemahaman Konsep Matematika Siswa dalam Pembelajaran Matematika Materi Bangun Ruang Sisi Datar SMP Swasta Budi Agung Medan* [Undergraduate thesis, Universitas Muhammadiyah Sumatera Utara]. https://repository.umsu.ac.id/handle/123456789/25203

Putri, T., Mandasari, N., & Maharani, T. (2024). Pengaruh Model Pembelajaran Problem Based Learning (PBL) Berbantuan Smart Board terhadap Hasil Belajar Matematika Siswa Kelas III SD Negeri 17 Kota Lubuklinggau. *Linggau Journal of Elementary School Education, 4*(1), 228–244. https://doi.org/10.55526/ljese.v4i1.691

Rianti, D. F., Putri, K. E., & Sulistiono. (2026). Analisis Kebutuhan Pengembangan Multimedia Interaktif Berbantuan Augmented Reality untuk Meningkatkan Pemahaman Konsep Siklus Air Siswa Sekolah Dasar. *Indonesian Journal of Innovation Multidisipliner Research, 4*(3), 1735–1746. https://multidisipliner.org/ijim/article/view/1442

Rohendi, D., Ramadhan, M. O., Rahim, S. S. A., & Zulnaidi, H. (2025). Enhancing student's interactivity and responses in learning geometry by using augmented reality. *Eurasia Journal of Mathematics, Science and Technology Education, 21*(1), Article em2559. https://doi.org/10.29333/ejmste/15796

Sagita, N., & Ikashaum, F. (2023). Pengaruh Model Pembelajaran Problem Based Learning terhadap Hasil Belajar Matematika Siswa. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika, 3*(2), 148–157. https://doi.org/10.51574/kognitif.v3i2.955

Simamora, Y., Simamora, M. I., & Andriani, K. (2022). Pengaruh Model Problem Based Learning (PBL) Berbasis Etnomatematika untuk Meningkatkan Kemampuan Literasi Numerasi Matematik Siswa SMP. *Jurnal Pembelajaran dan Matematika Sigma (JPMS), 8*(2), 532–538. https://doi.org/10.36987/jpms.v8i2.3675

Smith, K., Maynard, N., Berry, A., Stephenson, T., Spiteri, T., Corrigan, D., Mansfield, J., Ellerton, P., & Smith, T. (2022). Principles of problem-based learning (PBL) in STEM education: Using expert wisdom and research to frame educational practice. *Education Sciences, 12*(10), Article 728. https://doi.org/10.3390/educsci12100728

Telaumbanua, O., Telaumbanua, Y. N., Zega, Y., & Mendrofa, R. N. (2025). Analisis Kesiapan Guru Matematika dalam Mengadopsi Kurikulum Merdeka di Sekolah Menengah Atas Kota Gunungsitoli. *Sigma: Jurnal Pendidikan Matematika, 16*(2), 357–370. https://doi.org/10.26618/sigma.v16i2.15781