

DEVELOPMENT OF PROBLEM BASED LEARNING-BASED E-MEDIA TO IMPROVE STUDENTS' MATHEMATICS LEARNING OUTCOMES IN JUNIOR HIGH SCHOOL

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ABSTRACT

Mathematics learning in junior high schools still faces various challenges, particularly in students' low achievement and difficulties in understanding abstract concepts such as linear equations. This condition is reflected in Indonesia's low performance in international assessments such as PISA and TIMSS, as well as the low mathematics achievement of students at RK Fransiskus Xaverius Namorambe Private Middle School. The learning process remains teacher-centered and has not optimally utilized interactive digital learning media. Therefore, this study aims to develop a Problem Based Learning (PBL)-based E-Media using Google Sites to improve mathematics students' learning outcomes on the topic of Linear Equations. This study employed a Research and Development (R&D) method using the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation stages. The research subjects were eighth-grade students of RK Fransiskus Xaverius Private Middle School. Data were collected through interviews, observations, validation sheets, questionnaires, and learning outcome tests. Data analysis techniques included validity analysis, practicality analysis, effectiveness analysis, normality and homogeneity tests, and hypothesis testing. The novelty of this research lies in integrating Google Sites with the Problem Based Learning model to create an adaptive, interactive, and student-centered digital learning environment. The developed media is expected to be valid, practical, and effective in improving students' understanding, motivation, critical thinking skills, and mathematics learning outcomes. This study also provides implications for the development of technology-based mathematics learning media in junior high schools.

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INTRODUCTION

Education plays a fundamental role in improving the quality of human resources and national development. Through education, students are expected to develop critical thinking, problem-solving, communication, and creativity skills that are needed in the 21st century (Siregar et al., 2023). Mathematics is one of the essential subjects that contributes

significantly to the development of logical, analytical, systematic, and critical thinking abilities. In addition, mathematics supports the advancement of science and technology and has broad applications in everyday life. Therefore, mathematics learning should be designed to help students actively construct knowledge and solve contextual problems meaningfully (Komalasari, 2021).

However, mathematics learning outcomes in Indonesia remain relatively low. This condition is reflected in the results of international assessments such as the Program for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). Indonesia ranked 68th in mathematics in the PISA 2022 assessment with a score far below the international average (Eichler et al., 2023; Wibowo et al., 2025). Similarly, TIMSS results indicated that Indonesian students still experience difficulties in understanding mathematical concepts and solving higher-order thinking problems. These findings indicate that mathematics learning in schools still requires significant improvement, particularly in developing students' conceptual understanding and problem-solving skills (Alfiyah & Arisa, 2025).

One of the mathematics topics frequently considered difficult by junior high school students is Linear Equations. Students often experience difficulties in understanding gradients, determining equations of lines, interpreting graphs, and connecting algebraic representations with real-life situations (Palinussa et al., 2023; Zetriuslita et al., 2023). According to Alam (2023), students' difficulties in learning linear equations are closely related to weak conceptual understanding and low mathematical communication skills. Many students tend to memorize formulas procedurally without understanding the underlying concepts, which negatively affects their learning outcomes.

The preliminary observation conducted at RK Fransiskus Xaverius Namorambe Private Middle School also revealed similar problems. The average mathematics achievement of students during the last three academic years remained below the Minimum Mastery Criterion (KKM) score of 75. Classroom observations and interviews with mathematics teachers showed that the learning and teacher-centered methods. Teachers mainly used textbooks and PowerPoint slides without integrating interactive digital media into classroom instruction. As a result, students were less active, less motivated, and had difficulties understanding abstract mathematical concepts.

In the current digital era, the integration of technology into learning activities has become increasingly important. Technology-based learning media can help teachers create more interactive, engaging, and student-centered learning environments. One digital platform that can be utilized effectively in education is Google Sites. Google Sites provides opportunities for teachers to organize learning materials, videos, worksheets, quizzes, and interactive activities in one accessible online platform. According to Rosyiddin et al. (2023), Google Sites is easy to use, accessible through various devices, and suitable for supporting digital learning activities. Furthermore, interactive digital media can improve students' motivation, participation, and understanding of mathematical concepts Azizah et al. (2022).

To maximize the effectiveness of digital learning media, an appropriate learning model is also needed. Problem Based Learning (PBL) is considered suitable because it emphasizes authentic problem-solving activities and encourages students to think critically and collaboratively. PBL enables students to actively construct knowledge through investigation and discussion processes. Himmi et al. (2025) stated that Problem Based Learning helps students develop higher-order thinking skills, problem-solving abilities, and meaningful learning experiences. Therefore, integrating Google Sites with the PBL approach is expected to create an innovative learning environment that supports students' understanding of Linear Equations.

Based on these problems, this study aims to develop a Problem Based Learning-based E-Media using Google Sites to improve mathematics learning outcomes of eighth-grade students at RK Fransiskus Xaverius Namorambe Private Middle School. This study is expected to produce learning media that are valid, practical, and effective in supporting mathematics learning. In addition, the results of this research are expected to contribute theoretically to the development of educational technology and practically to improving the quality of mathematics learning in junior high schools.

METHOD

This study employed a Research and Development (R&D) approach to develop Problem Based Learning (PBL)-based E-Media using Google Sites for teaching Linear Equations in mathematics. The development process adopted the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation, to ensure a systematic process in designing, validating, implementing, and refining the instructional media. The study was conducted during the second semester of the 2025/2026 academic year at SMP Swasta RK Fransiskus Xaverius Namorambe, North Sumatra, Indonesia, involving eighth-grade students. A quasi-experimental pretest posttest control group design was employed

during the product testing phase, in which the experimental class used the developed PBL based E-Media, while the control class received conventional instruction (Ilhami., 2024; Millah et al., 2025).

The research subjects were selected using purposive sampling based on students' comparable academic abilities and teacher recommendations. The study involved material experts, media experts, and instructional design experts to validate the developed product, while mathematics teachers and students participated in evaluating its practicality. Data were collected through validation sheets, questionnaires, observation sheets, interview guides, documentation, and pretest–posttest learning outcome tests. These instruments were used to evaluate the validity, practicality, and effectiveness of the developed learning media.

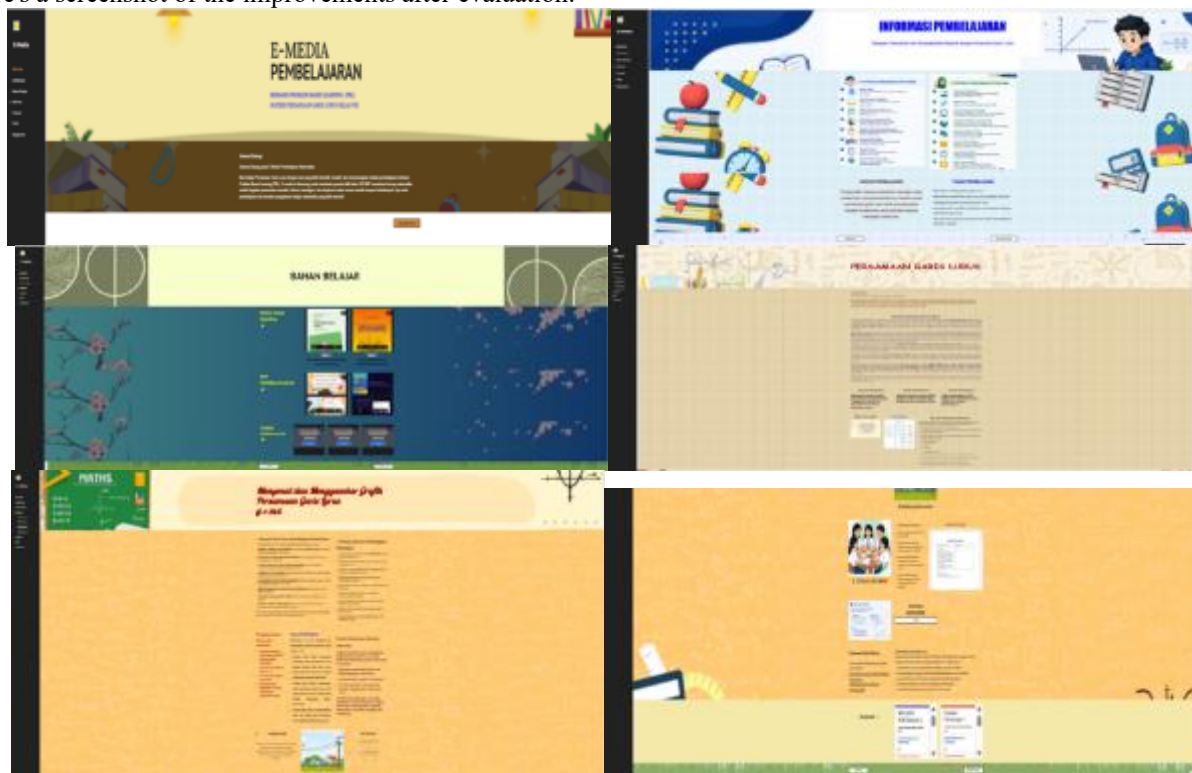
Data were analyzed using both qualitative and quantitative techniques. Qualitative data obtained from interviews, observations, and expert feedback were analyzed descriptively to improve the product, whereas quantitative data from validation sheets, questionnaires, and learning outcome tests were analyzed statistically. Prior to hypothesis testing, prerequisite analyzes including validity, reliability, item difficulty, discrimination power, normality, and homogeneity tests were conducted. The effectiveness of the developed E-Media was determined using an independent samples t-test to compare students' learning outcomes between the experimental and control groups, with all statistical analyzes performed using SPSS.

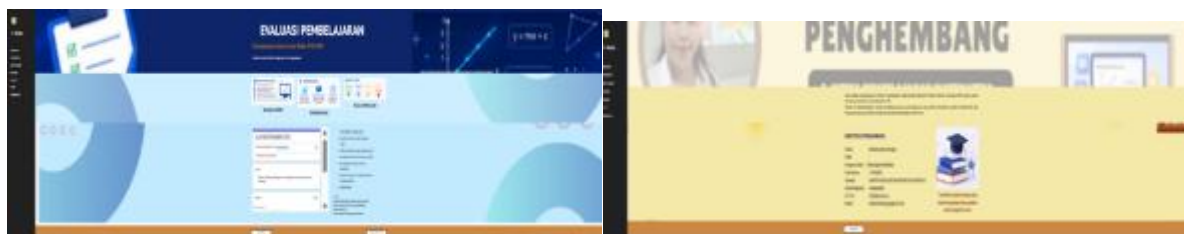
RESULTS AND DISCUSSIONS

Results

The development of the Problem Based Learning (PBL)-based E-Media using Google Sites was conducted through the ADDIE model, consisting of Analysis, Design, Development, Implementation, and Evaluation stages. The developed media contained learning materials, instructional videos, interactive worksheets, quizzes, and evaluation exercises related to the topic of Linear Equations for eighth-grade students.

Here's a screenshot of the improvements after evaluation:





The feasibility of the developed media was evaluated by material experts, media experts, and instructional design experts. The results of expert validation are presented in Table 1.

Table 1. Validation Results of the Developed E-Media

No.	Validation Aspect	Percentage Score	Category
1	Material Validation	92%	Very Valid
2	Media Validation	90%	Very Valid
3	Instructional Design Validation	88%	Very Valid
	Average	90%	Very Valid

Based on Table 1, the average validation score of the developed E-Media was 90%, indicating that the product was categorized as very valid and feasible for implementation in mathematics learning.

The practicality of the E-Media was measured through teacher and student response questionnaires after the implementation process. The results are presented in Table 2.

Table 2. Practicality Results of the Developed E-Media

No.	Respondents	Percentage Score	Category
1.	Teacher Responses	94%	Very Practical
2.	Student Responses	89%	Very Practical
	Average	91.5%	Very Practical

The results showed that both teachers and students responded positively to the developed media. Students stated that the learning media were interesting, easy to access, interactive, and helped them understand mathematical concepts more easily.

The effectiveness of the developed E-Media was measured using students' pretest and posttest scores in both experimental and control classes. The experimental class consisted of 30 students who learned using the PBL E-Media, while the control class consisted of 30 students who learned using conventional methods.

Table 3. Students' Learning Outcomes

Class	Pretest Mean Score	Posttest Mean Score	Improvement
Experimental Class	58.40	84.70	26.30
Control Class	57.90	72.10	14.20

The data in Table 3 indicates that students in the experimental class experienced higher improvement compared to students in the control class. The increase in the experimental class reached 26.30 points, while the control class only improved by 14.20 points.

Before hypothesis testing, prerequisite tests were conducted. The normality test using Kolmogorov Smirnov showed significance values greater than 0.05, indicating that the data were normally distributed.

Table 4. The normality test

Tests of Normality

Kelas		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Hasil Belajar Matematika	1	.121	30	.200*	.957	30	.257
	2	.138	30	.147	.957	30	.260
	3	.111	30	.200*	.943	30	.113
	4	.145	30	.107	.940	30	.093

The homogeneity test also showed that the data were homogeneous with a significance value of $0.217 > 0.05$.

Table 5. Homogeneity Test Results

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Hasil Belajar Matematika	Based on Mean	.497	1	58	.484
	Based on Median	.281	1	58	.598
	Based on Median and with adjusted df	.281	1	49.761	.598
	Based on trimmed mean	.474	1	58	.494

The homogeneity test was conducted to determine whether the variances of the experimental and control groups were equal. The results presented in Table 4.14 show that, for the pretest data, the variance of the control group was 134.79, while the variance of the experimental group was 123.96. The calculated F-value (1.087) was lower than the critical F-table value (1.861), indicating that the pretest data were homogeneous.

Similarly, for the post test data, the variance of the control group was 49.58, whereas the variance of the experimental group was 32.81. The calculated F-value (1.511) was also lower than the F-table value (1.861). Therefore, the post test data were considered homogeneous.

These findings indicate that the variances of both groups were homogeneous, satisfying one of the assumptions required for conducting the independent samples t-test.

Furthermore, hypothesis testing using the independent sample t-test showed a significance value of $0.000 < 0.05$. Therefore, there was a significant difference between the learning outcomes of students taught using the PBL-based E-Media and those taught using conventional learning methods.

Table 6. Hypothesis Testing

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
Mark	Equal variances assumed	.497	.484	-9,011	58
	Equal variances not assumed			-9,011	55,692

Independent Samples Test

		t-test for Equality of Means			
		Sig. (2-tailed)	Mean Difference	Standard Error Difference	95% Confidence Interval of the Difference
					Lower
Mark	Equal variances assumed	.000	-14,933	1,657	-18,251
	Equal variances not assumed	.000	-14,933	1,657	-18,254

An independent samples t-test was conducted to determine whether there was a significant difference in learning outcomes between students in the experimental class and those in the control class after the implementation of the Problem Based Learning (PBL)-based E-Media.

As shown in Table 4.15, the calculated t-value was 9.01, with 58 degrees of freedom. The critical t-table value at a significance level of $\alpha = 0.05$ was 2.92. Since the calculated t-value (9.01) was greater than the critical t-table value (2.92), the null hypothesis (H_0) was rejected.

These results indicate a statistically significant difference between the learning outcomes of students in the experimental and control groups. Therefore, it can be concluded that the PBL-based E-Media had a significant positive effect on students' mathematics learning outcomes.

Table 7. t-Test and N-Gain Score Results

Case Processing Summary

Class		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
N_Gain	Control	30	100.0%	0	0.0%	30	100.0%
	Experiment	30	100.0%	0	0.0%	30	100.0%

Case Processing Summary

Class		Cases					
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N_Gain	Control	30	100.0%	0	0.0%	30	100.0%
	Experiment	30	100.0%	0	0.0%	30	100.0%

The effectiveness of the PBL-based E-Media was further analyzed using the N-Gain score to measure the improvement in students' learning outcomes from pretest to posttest.

As presented in Table 4.16, the control group obtained an average N-Gain score of 0.480, which falls into the moderate category. In contrast, the experimental group achieved an average N-Gain score of 0.748, which is categorized as high. These findings indicate that students who learned using the PBL-based E-Media experienced a greater improvement in learning outcomes compared to those who received conventional instruction.

Furthermore, the independent samples t-test yielded a calculated t-value of 9.01, which exceeded the critical t-value of 2.92 at the 0.05 significance level. As a result, the null hypothesis (H_0) was rejected, indicating a statistically significant difference between the experimental and control groups.

Therefore, it can be concluded that the PBL-based E-Media was effective in improving students' mathematics learning outcomes and produced a significantly higher learning gain compared to conventional learning methods.

Figure 1 illustrates the comparison of students' posttest scores between the experimental and control classes. Comparison of Students' Posttest Scores Between Experimental and Control Classes. The graph showed that the experimental class achieved significantly higher learning outcomes than the control class after the implementation of the developed E-Media.

Discussion

The results of this study indicate that the PBL-based E-Media developed using Google Sites is valid, practical, and effective for improving mathematics students' learning outcomes on the topic of Linear Equations. The high validation scores obtained from material experts, media experts, and instructional design experts demonstrate that the developed media met the criteria of content quality, visual design, instructional suitability, and usability (Maulidya & Astuti, 2025; Yonanda et al., 2024).

The practicality results also revealed that the developed media could facilitate learning activities effectively. Students showed high enthusiasm during the learning process because the media integrated videos, interactive exercises, and problem-solving activities into one online platform (Katona et al., 2023). This finding supports the theory proposed by Akram et al. (2022), stating that interactive learning media can improve students' motivation and engagement in learning activities.

The significant improvement in students' learning outcomes in the experimental class indicates that integrating Problem Based Learning with Google Sites successfully enhanced students' conceptual understanding and problem-solving abilities. Through Problem Based Learning, students were encouraged to actively identify problems, discuss

solutions collaboratively, and construct mathematical concepts independently. This finding is consistent with Vygotsky's constructivist theory, which emphasizes the importance of social interaction and scaffolding in developing students' cognitive abilities (Evendi et al., 2022; Hoerudin et al., 2023).

The implementation of Google Sites also provided flexibility for students to access learning materials anytime and anywhere. This flexibility supported independent learning and allowed students to review materials repeatedly according to their learning pace. As stated by Darmayanti (2024), digital learning media supports self-directed learning and increases students' learning autonomy.

The novelty of this research lies in the integration of Google Sites and Problem Based Learning into an interactive mathematics E-Media specifically designed for Linear Equations learning in junior high schools. Unlike conventional learning media, the developed product combines instructional videos, contextual problem-solving activities, worksheets, and online evaluations within a single digital platform. This integration creates a more meaningful and student-centered learning environment.

The implications of this study indicate that technology-based learning media can become an effective alternative for improving mathematics learning quality in junior high schools. Teachers are encouraged to integrate interactive digital platforms and student-centered learning models into classroom instruction to improve students' critical thinking skills, learning motivation, and academic achievement. Furthermore, this research can serve as a reference for future studies related to the development of digital learning media in mathematics education and other subject areas.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the Problem Based Learning (PBL)-based E-Media developed using Google Sites is valid, practical, and effective for improving mathematics learning outcomes on the topic of Linear Equations for eighth-grade students at RK Fransiskus Xaverius Namorambe Private Middle School. The validity results obtained from material experts, media experts, and instructional design experts showed that the developed media met the criteria for appropriate instructional content, attractive visual appearance, and effective learning design. In addition, the practicality results indicated that both teachers and students responded positively to the use of the E-Media because it was interactive, accessible, and easy to use during the learning process.

The effectiveness test also demonstrated that students who learned using the PBL-based E-Media achieved significantly higher learning outcomes compared to students who learned through conventional methods. The integration of Google Sites with the Problem Based Learning model encouraged students to become more active, independent, collaborative, and motivated in solving mathematical problems. Furthermore, this study contributes to the development of technology-based mathematics learning media that supports student-centered learning and 21st-century educational demands. Therefore, the developed E-Media can be recommended as an alternative digital learning medium for mathematics instruction in junior high schools. Future researchers are encouraged to develop similar media for other mathematics topics and broader educational contexts.

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