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DEVELOPMENT OF PBL-BASED INTERACTIVE E-MODULES TO IMPROVE CRITICAL THINKING SKILLS OF GRADE 4 STUDENTS IN MATHEMATICS AT SDN 060866 MEDAN

Try Rahayu[1*], Albert Pauli Sirait[2], Wildansyah Lubis[3], Elvi Mailani[4], Apiek Gandamana[5]
[12345] Program Studi Pendidikan Guru Sekolah Dasar, Fakultas Ilmu Pendidikan, Universitas Negeri Medan, Medan, Indonesia
*Correspondence Email: tryrahayu@mhs.unimed.ac.id

ABSTRACT

This research is motivated by the low critical thinking skills and learning outcomes of students in mathematics subjects in grade IV of SDN 060866 Medan, which is caused by learning that is still centered on the teacher and the unavailability of interactive learning media that supports the learning process. This study aims to determine the feasibility, practicality, and effectiveness of developing interactive e-modules based on Problem Based Learning (PBL) to improve critical thinking skills of grade IV students in mathematics subjects. The type of research used is Research and Development (R&D) with the ADDIE development model which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects were a material expert, a question expert, a design expert, teachers and grade IV students of SDN 060866 Medan, totaling 23 students. Data collection instruments included validation sheets of material experts, question experts, design experts, teacher practicality questionnaires, as well as pre-test and post-test tests to measure effectiveness. The research results showed that the developed e-module was deemed highly feasible, with validation results from material experts reaching 87.69%, validation from question experts reaching 84.61%, and validation from design experts reaching 95.65%. The practicality test yielded a score of 98.6%, categorized as very practical. Furthermore, the e-module also proved highly effective, with a student learning completion rate of 91% and an average score increase from 53.75 in the pre-test to 87.75 in the post-test, representing a 34-point increase. Therefore, the developed interactive e-module based on Problem-Based Learning was deemed feasible, practical, and effective for use in mathematics learning to improve the critical thinking skills of fourth-grade students at SDN 060866 Medan.

Keywords: interactive e-module; Problem-Based Learning; critical thinking; mathematics; elementary school.

INTRODUCTION

Mathematics learning in elementary schools plays a crucial role in developing students' logical, analytical, and critical thinking skills. Through mathematics learning, students are expected to not only understand the concepts of numbers and arithmetic operations, but also develop reasoning and problem-solving skills in everyday life. Therefore, the mathematics learning process needs to be designed effectively to encourage students to think critically and actively in their learning activities. However, the implementation of mathematics learning in elementary schools still faces various challenges. Based on observations in fourth-grade students at SDN 060866 Medan, it was found that students still struggle to understand mathematics because the material taught demands logical and critical thinking skills, while learning media that support the development of these skills are lacking. Furthermore, the learning process is still dominated by teacher-centered learning (TCL) methods, resulting in students' passive learning. Teachers also continue to provide conventional practice exercises without the support of interactive learning media, resulting in low student motivation and underdevelopment of critical thinking skills.

One learning model that can be used to address these issues is Problem-Based Learning (PBL). The PBL model is a learning approach that places students at the center of the learning process by confronting them with contextual problems relevant to everyday life. Through this problem-solving process, students are encouraged to think critically and creatively, and develop their analytical and logical reasoning skills. Rahmadani (2023, p. 47) states that the PBL model is a learning approach that confronts students with real-world problems, thereby practicing critical thinking and problem-solving skills. Furthermore, Nurjannah and Trimulyono (2022, pp. 88–89) explain that each stage in the PBL model is designed to guide students in analyzing problems, identifying solutions, and producing results, thus establishing a strong connection with students' critical thinking skills.

In addition to using appropriate learning models, the use of digital learning media is also crucial in supporting a more engaging and interactive learning process. One such medium is interactive e-modules. Interactive e-modules are digital teaching materials equipped with various multimedia features such as text, images, videos, animations, and practice questions that can help students understand the learning material independently. According to Mulyasari (2023, p. 23), interactive e-modules are digital-based teaching materials equipped with multimedia features that can help students understand learning concepts in a more engaging way. Furthermore, Almunawarah and Bahri (2023, pp. 61–62) state that e-modules allow students to learn anytime and anywhere at their own pace, thereby increasing motivation and active engagement in the learning process.

Several previous studies have also shown that the use of Problem-Based Learning-based e-modules has proven effective in improving students' critical thinking skills. Research by Nurjannah and Trimulyono (2022, p. 89) concluded that the PBL model plays a crucial role in developing critical thinking skills because it requires students to analyze problems, find solutions, and make decisions based on the evidence obtained. Furthermore, research by Restina et al. (2021, p. 5) states that PBL-based interactive e-modules can create a more active and meaningful learning environment and encourage students to understand concepts in depth. Similar findings were also expressed by Purwanto et al. (2023, p. 112), that the combination of PBL and digital media can improve higher-order thinking skills, including critical thinking and problem-solving.

Based on these various issues and supported by previous research, innovations in mathematics learning are needed that can improve students' critical thinking skills while utilizing digital technology as a learning medium. Therefore, the researcher is interested in conducting a developmental research project entitled "Development of an Interactive E-Module Based on Problem-Based Learning (PBL) to Improve Critical Thinking in Fourth Grade Students in Mathematics at SDN 060866 Medan." This research is expected to produce appropriate, practical, and effective learning media to support the mathematics learning process in elementary schools. Based on this background, the formulation of the problem in this study is: (1) how is the feasibility of developing PBL-based interactive e-modules to improve the critical thinking skills of fourth grade students in mathematics at SDN 060866 Medan; (2) what is the level of practicality of the PBL-based interactive e-modules developed; and (3) how effective is the use of PBL-based interactive e-modules in improving students' critical thinking skills.

RESEARCH METHODS

This study used a Research and Development (R&D) approach with the aim of developing an interactive e-module based on Problem-Based Learning (PBL) in mathematics learning to improve students' critical thinking skills. The development model used was the ADDIE model, which includes analysis, design, development, implementation, and evaluation. The study was conducted at SD Negeri 060866 Medan Timur, located at Jalan Gunung Krakatau No. 28/196, Pulo Brayan Darat I, Medan Timur District, Medan City. The research subjects were subject matter experts, problem experts, design experts, teachers, and 23 fourth-grade B students. The research object was an interactive e-module on whole numbers. Data collection techniques included expert validation, a teacher practicality questionnaire, and pre- and post-tests to measure students' critical thinking skills. The instruments used were an expert validation sheet, a practicality assessment questionnaire, and a learning outcome test. The data obtained were analyzed using quantitative descriptive analysis to determine the validity, practicality, and effectiveness of the developed e-module.

RESULTS AND DISCUSSION

Test Item Validity

Test item validity is a crucial aspect in ensuring the accuracy of the questions used to measure the intended ability. Validity testing is conducted by comparing the calculated r value with the r table at a 5% significance level. If the calculated r value is greater than the r table, the test item is considered valid. The test items declared valid are shown in Table 1 below:

Table 1 Results of Test Item Validation Calculations

No. Item	r_{hitung}	r_{tabel} 5% (23)	Sig.	Criteria
1	0,103	0,413	0,639	Invalid
2	0,617	0,413	0,002	***Valid***
3	0,566	0,413	0,005	***Valid***
4	0,225	0,413	0,301	Invalid
5	0,547	0,413	0,007	***Valid***
6	0,738	0,413	0,000	***Valid***
7	0,543	0,413	0,007	***Valid***
8	0,120	0,413	0,587	Invalid
9	0,014	0,413	0,948	Invalid
10	0,158	0,413	0,473	Invalid
11	0,543	0,413	0,007	***Valid***
12	0,120	0,413	0,585	Invalid
13	0,754	0,413	0,000	***Valid***
14	0,592	0,413	0,003	***Valid***
15	0,234	0,413	0,283	Invalid
16	0,707	0,413	0,000	***Valid***
17	0,212	0,413	0,332	Invalid
18	0,225	0,413	0,301	Invalid
19	0,648	0,413	0,001	***Valid***
20	0,268	0,413	0,216	Invalid
21	0,669	0,413	0,000	***Valid***
22	0,304	0,413	0,159	Invalid
23	0,472	0,413	0,023	***Valid***
24	0,120	0,413	0,587	Invalid
25	0,657	0,413	0,001	***Valid***

26	0,268	0,413	0,216	Invalid
27	0,617	0,413	0,002	***Valid***
28	0,578	0,413	0,004	***Valid***
29	0,316	0,413	0,142	Invalid
30	0,317	0,413	0,141	Invalid
31	0,041	0,413	0,854	Invalid
32	0,547	0,413	0,007	***Valid***
33	0,707	0,413	0,000	***Valid***
34	-0,059	0,413	0,790	Invalid
35	0,234	0,413	0,283	Invalid
36	0,648	0,413	0,001	***Valid***
37	0,496	0,413	0,016	***Valid***
38	-0,273	0,413	0,207	Invalid
39	0,304	0,413	0,159	Invalid
40	0,158	0,413	0,473	Invalid
41	0,316	0,413	0,142	Invalid
42	0,333	0,413	0,121	Invalid
43	0,325	0,413	0,130	Invalid
44	-0,306	0,413	0,155	Invalid
45	0,265	0,413	0,223	Invalid
46	0,124	0,413	0,573	Invalid
47	0,251	0,413	0,248	Invalid
48	0,375	0,413	0,078	Invalid
49	0,336	0,413	0,117	Invalid
50	0,608	0,413	0,002	***Valid***

Based on the results of a validity test conducted on 23 respondents at a 5% significance level (r table = 0.413), it was found that of the 50 research instrument items, 20 were declared valid because they had a calculated r value > 0.413 and a significance value (Sig.) < 0.05. These were items 2, 3, 5, 6, 7, 11, 13, 14, 16, 19, 21, 23, 25, 27, 28, 32, 33, 36, 37, and 50. Meanwhile, the remaining 30 items had a calculated r value < 0.413 and were therefore declared invalid and were not used in this study. Therefore, based on the data in Table 1, only the 20 items that met the validity criteria will proceed to the reliability test stage to measure the instrument's consistency before being used in research data collection.

Test Reliability

After the test validity is complete, the next step is to test the test's reliability. This test aims to determine the extent to which the test used by the researcher is trustworthy and reliable, and to determine whether the results remain consistent after retesting. To test the test's reliability, the researcher used SPSS 25. A test is considered reliable if α > r table; conversely, if α < r table, the test is unreliable. The following are the results of the test's reliability test conducted using SPSS 25.

Table 2 Reliability Test Results

Cronbach's Alpha	N of Items
,922	20

Based on the figure above, it can be concluded that the 20 tests tested for reliability achieved an alpha value of 0.922, which falls within the range of 0.90 < $r11$ ≤ 1.00, with a reliability

classification of "very high." The effectiveness of implementing problem-based learning e-modules was tested on 23 students in grade IVB. The test consisted of 20 multiple-choice questions. The results of the pre-test and post-test are presented in the following table:

Table 3 Criteria for Achieving Learning Objectives Pre-test

No.	Interval Score	Frequency	Percentage	Description
1	≥ 70	6	26%	Completed
2	≤ 70	17	74%	Not yet completed

Based on the information in Table 3 the results show that the completion rate for students with scores above 70 reached 26%, while those with scores below 70 reached 74%. The data above demonstrates that before using the interactive e-module based on problem-based learning, students' critical thinking skills regarding whole numbers were still low.

Table 4 Criteria for Achieving Learning Objectives Post-test

No.	Interval Score	Frequency	Percentage	Description
1	≥ 70	21	91%	Completed
2	≤ 70	2	9%	Not yet completed

Based on the information in Table 4, the results show that the completion rate of ≥ 70 reached 91%, while the score ≤ 70 reached 9%. The data above proves that the level of critical thinking skills of students after using interactive e-modules based on problem-based learning in learning provides an increase in understanding of the material on whole numbers for grade IV. The pre-test and post-test results data are presented in the following table:

Table 5 Pre-test and Post-test Values

No.	Name of student	Score		Description
		Pre-test	*Post-test*	
1	Student 01	35	80	Increase
2	Student 02	80	100	Increase
3	Student 03	40	85	Increase
4	Student 04	70	100	Increase
5	Student 05	20	60	Increase
6	Student 06	45	80	Increase
7	Student 07	60	100	Increase
8	Student 08	75	100	Increase
9	Student 09	60	90	Increase
10	Student 010	35	80	Increase
11	Student 011	55	90	Increase
12	Student 012	15	65	Increase
13	Student 013	75	100	Increase
14	Student 014	75	100	Increase
15	Student 015	85	100	Increase
16	Student 016	35	80	Increase
17	Student 017	50	85	Increase
18	Student 018	65	90	Increase
19	Student 019	55	90	Increase
20	Student 020	45	80	Increase
Lowest Score		**15**	**60**	**Increase**
Highest Score		**85**	**100**	**Increase**
Average		**53,75**	**87,75**	**Increase**
Total Score		**1075**	**1755**	**Increase**

Table 5 shows that the post-test scores were higher than the pre-test scores. This is evident from the average student score, which increased from 53.75 in the pre-test to 87.75 in the post-test, a 34-point increase. Furthermore, the total score also increased from 1075 to 1755. Therefore, it can be concluded that student learning outcomes improved after being given treatment using the

developed learning media. To clarify the comparison of pre-test and post-test scores, see the following graph:

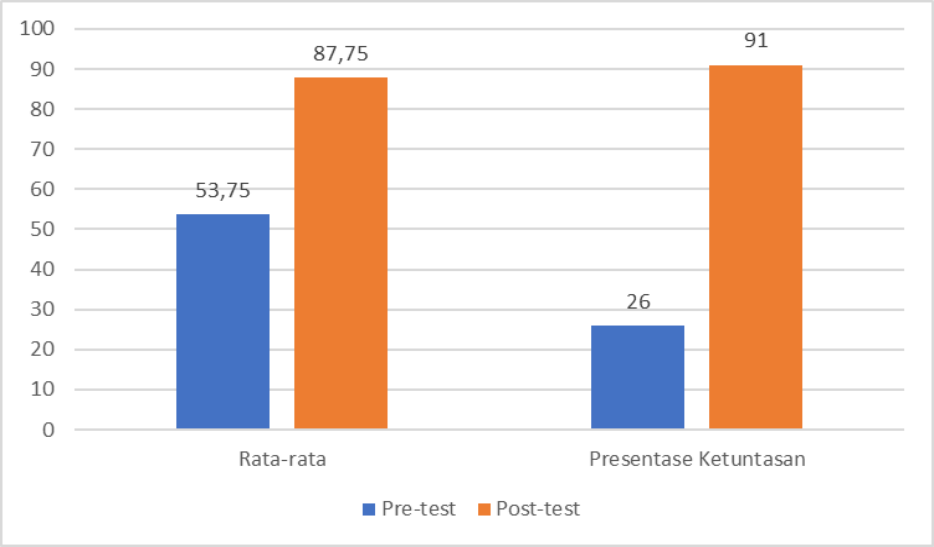

Figure 1 Graph of Student Learning Outcomes

Therefore, it can be concluded that the interactive e-module based on problem-based learning for whole numbers in fourth grade at SD Negeri 060866 Medan is effective as a teaching module. The next stage was the evaluation phase, which summarized the research data obtained from validators, including lecturers, teachers, and students. This was done to determine the validity, effectiveness, and practicality of the interactive e-module development based on problem-based learning for whole numbers in fourth grade at SD Negeri 060866 East Medan. A summary of the e-module development at each stage can be seen in the table below:

Table 6 Summary of PBL-Based E-module Development Validation

No.	Validator	Validation Results	
		Percentage	Criteria
1	Question Expert	84,61%	Very Appropriate
2	Material Expert	87,69%	Very Appropriate
3	Design Expert	95,65%	Very Appropriate
4	Teacher	98,6%	Very Practical
5	Student Learning Outcomes	91%	Very Effective

Based on Table 6 above, the validation results by experts and practitioners showed very positive results overall. These details include a validity test by question experts of 84.61% (Very Appropriate), material experts of 87.69% (Very Appropriate), and design experts of 95.65% (Very Appropriate). Meanwhile, the practicality test through a classroom teacher questionnaire obtained a result of 98.6% (Very Practical) and the effectiveness test based on student learning outcomes reached 91% (Very Effective). Thus, this e-module is declared very feasible, practical, and effective for use.

CONCLUSIONS

Based on the problem formulation, data analysis, and discussion, this development research concludes that the interactive e-module based on Problem-Based Learning, supported by Canva, Heyzine, and educational games such as Wordwall and Froggy Jumps, was highly feasible, very practical, and very effective for improving the critical thinking skills of fourth-grade students at SDN 060866 Medan. Its feasibility was shown by expert validation results, including question validation at 84.61%, material validation at 87.69%, and design validation at 95.65%. Its practicality was confirmed by a teacher response questionnaire score of 98.6%, which reflected positive evaluations in terms of accessibility, instructions, language, material, benefits, and media appearance. Its effectiveness was demonstrated by the increase in classical learning completion to 91% and the improvement in the average student score by 34 points, from 53.75 on the pre-test to 87.75 on the post-test after the use of the developed learning media.

BIBLIOGRAPHY

Almunawarah, A., & Bahri, S. (2023). Development of e-modules as digital learning media to improve student learning motivation. Journal of Education and Learning Technology, 5(1), 58–65.

Arikunto, S. (2013). Research Procedures: A Practical Approach. Jakarta: Rineka Cipta.

Ananda, R. (2017). Analysis of Validity and Reliability of Research Instruments. Journal of Educational Research, 18(2), 100–110.Facione, P. A. (2020). Critical Thinking: What It Is and Why It Counts. Millbrae, CA: Insight Assessment.

Fitriani, S., Rahmawati, D., & Putra, A. 2024. Development of Interactive E-Modules Based on Problem-Based Learning (PBL) on Fractions for Fourth Grade Elementary School Students. Journal of Elementary School Mathematics Education, 5(1), 1–10.

Gustiani, S. (2023). Research and Development (R&D) Method in Educational Research: A Model of ADDIE. Journal of Education and Learning, 7(1), 45–56.

Kadir, A., et al. (2022). Mathematics learning in elementary schools and its implementation. Journal of Mathematics Education, 6(1), 45–53.

Kholillah, I. S., et al. (2024). Utilization of the Maze Chase Game in Elementary School Children's Learning. Indonesian Journal of Educational Technology, 8(1), 18–25.

Kosasih, (2021). Learning Media and Teaching Materials Development. Bandung: Yrama Widya.

Kustiawan, D., Raihan, D., & Thariq, I. (2025). Research Location and Time in Educational Research: An Implementation Study. Journal of Educational Methodology, 11(2), 5049–5055.

Lubis, R. R., Parinduri, W. M., Rambe, T. R., Rambe, N., & Fadli, M. (2022). School Education Journal Pgsd Fip Unimed. The journal, 12(2).

Mailani, E., Saragih, D. I., Pandiangan, L. L., Bangun, S. L., Ade, N. F., Amelia, V. Q., ... & Utara, P. S. (2024). The Effect of Educational Game-Based Methods in Teaching Integer Operations to Improve Learning Outcomes of Sixth-Grade Students at SD IT Insan Madani. Journal of Citizen Research and Development, 1(2), 753-757.

Monica, & Mayar. (2019). Elementary School Child Development and Its Implications for Learning. Jurnal Obsesi: Jurnal Pendidikan Usia Dini (Obsession Journal: Journal of Early Childhood Education), 3(2), 1218–1223.

Mulyasari, D. (2023). Development of interactive e-modules as digital teaching materials in elementary school learning. Journal of Elementary Education, 7(1), 20–28.

Mulyatiningsih, E. (2014). Applied Research Methods in Education. Bandung: Alfabeta.

Mutiara, dkk. (2024). Pengaruh Kemajuan Teknologi terhadap Perubahan Pola Belajar Generasi Alpha. Jurnal Inovasi Pendidikan Indonesia, 10(4), 10043–10050.

Murtaqin, et al. (2024). The Influence of Technological Advances on Changes in Generation Alpha Learning Patterns. Indonesian Journal of Educational Innovation, 10(4), 10043–10050.

Muttaqin, et al. (2020). Development of Interactive Digital Modules as Learning Media. Indonesian Journal of Educational Technology, 9(2), 45–52.

Nurjannah, N., & Trimulyono, G. (2022). Application of the Problem-Based Learning model to improve students' critical thinking skills. Journal of Mathematics Education, 6(2), 85–92.

Oktaviasari, D., Pratiwi, A., & Hastungkoro, A. (2024). Application of Wordwall Media to Improve Student Learning Outcomes on the Concept of Mathematical Addition in Grade I of SDN Putat Jaya IV-380 Surabaya. Indonesian Journal of Elementary Education, 9(1), 33–41.

Prastowo, A. (2019). Creative Guide to Creating Innovative Teaching Materials. Yogyakarta: Diva Press.

Purwanto, A., et al. (2023). Developing elementary school students' critical thinking skills through contextual learning. Journal of Elementary Education, 14(2), 101–110.

Rahayu, T., et al. (2022). Innovation in digital-based learning media in elementary education. Journal of Educational Innovation, 8(3), 210–219.

Rahmadani, R. (2023). Implementation of the Problem-Based Learning model in learning to improve elementary school students' critical thinking skills. Journal of Elementary Education, 8(1), 40–48.

Restina, S., et al. (2021). The influence of digital learning media on student learning motivation. Journal of Educational Technology, 9(2), 88–97.

Riduwan, (2013). Measurement Scales for Research Variables. Bandung: Alfabeta.

Ruseffendi, E. T. (2024). Fundamentals of Modern Mathematics Education. Bandung: Tarsito.

Sari, R., & Nurfadilah, D. (2024). The Use of the Digital Maze Chase Game in Elementary Mathematics Learning. Edumath: Journal of Mathematics Education, 12(2), 56–63.

Sabirli, Z., dkk. (2020). Educational Games in Elementary Education: Impacts on Students' Learning Outcomes. International Journal of Instructional Media, 47(3), 325–330.

Siagian, P. S. (2012). Human Resource Management. Jakarta: Bumi Aksara.

Siregar, S. (2014). Quantitative Research Methods: Complete with a Comparison of Manual Calculations and SPSS. Jakarta: Kencana Prenadamedia Group.

Sugiyono. (2017). Quantitative, Qualitative, and R&D Research Methods. Bandung: Alfabeta.

Sugiyono. (2019). Quantitative, Qualitative, and Mixed Methods Research Methods. Bandung: Alfabeta.

Suharsimi, A. (2007). Research Procedures: A Practical Approach. Jakarta: Rineka Cipta.

Suharsimi. (2014). Research Procedures: A Practical Approach. Jakarta: Rineka Cipta.

Sumarno. (2012). Curriculum Development and Learning. Yogyakarta: Pustaka Pelajar.

Syaio, N. (2017). Educational Research Methods. Bandung: Remaja Rosdakarya.

Syahrir, & Susilawati. (2015). Interactive Learning Media. Jakarta: Kencana.

Syaodih, N. (2015). Educational Research Methods. Bandung: Remaja Rosdakarya.

Tarigan, H. G. (2014). Reading as a Language Skill. Bandung: Angkasa.

Usman, M., et al. (2021). The role of mathematics learning in developing students' logical thinking. Indonesian Journal of Elementary Education, 7(1), 33–41.

Vera Ziden. (2023). The ADDIE Model Implementation in Digital Learning Game Development. International Journal of Education and Learning Technology, 15(1), 55–67.

Widoyoko, S. E. P. (2009). Learning Program Evaluation. Yogyakarta: Pustaka Pelajar.

Wike Ardiyani, R., Rohana, & Dhony, N. N. A. (2024). Mathematical Problem-Solving Skills Through Wordwall-Based Educational Games. Journal of Mathematics and Science Education, 12(2), 80–89.

Wiwiwta, R., & Hanadayani, L. (2022). Teacher-Student Interaction in Effective Learning. Journal of Education and Learning, 11(2), 145–154.

Yuliani, N., & Pratama, R. (2023). The Effect of Educational Game-Based Learning Media on Student Learning Motivation. Journal of Innovative Education, 9(2), 210–219.