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Development of a comic interactive-based problem-based learning model to improve the critical thinking skills of elementary students

Amrin[1]*, Mochammad Noeryoko[1], Muh. Ma'ruf[1], Khaerunnisa[1], M. Ibnusaputra[1], Ibrahim Pandu Ame[2]
[1] STKIP Taman Siswa Bima, Indonesia.
[2] The State University of Zanzibar, Tanzania.
* Corresponding Author. E-mail: amrinputra93@gmail.com

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ABSTRACT

The era of the Industrial Revolution 5.0 requires the education sector to adapt to rapid technological developments, particularly through the adoption of innovative learning models. This study aims to develop a feasible, practical, and effective comic-based interactive Problem-Based Learning (PBL) model to improve elementary school students' critical thinking skills. The method used is research and development (R&D) with the ADDIE model, involving a qualitative approach to assess the product's feasibility and practicality, and a quantitative approach to measure its effectiveness through a pretest-posttest design. The research subjects were 30 fifth-grade students at Elementary School 9 Sila, Bima Regency. The instruments used included a feasibility questionnaire, a practicality questionnaire, and a critical thinking skills test. The results showed that the products developed for the PBL model (90.8%), interactive comics (96.5%), and critical thinking skills tests (95.7%) were feasible for use. The practicality level of interactive comics (93.25%) and critical thinking skills tests (97.75%) was very practical for use in elementary school learning. The n-Gain test results showed an increase in critical thinking skills with an average score of 0.74 (high category). This was supported by a significant paired-samples t-test ($p < 0.05$), which showed a difference between the students' pretest and posttest scores. In general, these results indicate that the application of the comic interactive-based PBL model is effective in improving students' critical thinking skills.

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INTRODUCTION

The rapid development of technology in the era of the Industrial Revolution 5.0 has brought significant changes in various aspects of life, including the world of education. This era is characterised by collaboration among advanced technology, artificial intelligence, and big data (Apriliyanti & M, 2022; Awotunde et al., 2023). As a result, it requires every individual to have adaptive skills to survive in a dynamic environment. Teachers, as the spearhead of education, are required to integrate learning models and media that align with the needs of the times, especially in developing a critical, creative, communicative, and collaborative student profile from elementary school age onward.

The Merdeka Curriculum responds to these needs by emphasising the development of 21st-century skills, including critical thinking. These skills include the ability to analyse information, evaluate arguments, solve problems, and make decisions reflexively (Alsaleh, 2020; Walter, 2024). At the elementary school level, critical thinking skills are very important to instil from an early age because they form the foundation for mastering more complex literacy and numeracy at the next level of education (Dewi & Wardani, 2021; Ramadhani & Setiawan, 2023; Puspita & Parma Dewi, 2021).

The spotlight on the skill achievement of Indonesian students at the international level still reveals a considerable gap. The results of the Programme for International Student Assessment (PISA) survey in 2022 place Indonesia relatively low in reading, science, and mathematics literacy. This fact underscores the need for innovative efforts to improve learning quality, enabling students to develop critical thinking skills and address global challenges. One step is to present a learning model that fosters critical thinking through meaningful learning experiences.

The Problem-Based Learning (PBL) model has been widely recognised as an effective model for fostering critical thinking skills (Ningrum et al., 2024; Setyawan & Koeswanti, 2021). Through the presentation of contextual problems, students are invited to explore information, discuss, find alternative solutions, and independently or collaboratively reach conclusions (Nora et al., 2023; Owens & Hite, 2022). However, previous implementations of PBL in elementary schools still face several obstacles, particularly regarding the availability of learning media that align with the characteristics of digital-generation students. Elementary school students tend to be more interested in visual, interactive media that are closely related to their daily lives (Galada & Baytar, 2025; Hoffmanová et al., 2025; Putri et al., 2025).

Based on this, this research identifies the interactive comic as one of the media with potential for use. This media not only presents an interesting visual narrative but also includes interactive elements that engage students in the learning process (Faradiba & Budiningsih, 2020; Matuk et al., 2021; Prinandari et al., 2024). Several studies have shown that interactive comics can embrace various learning styles, both visual, auditory, and kinesthetic, while embedding educational content in a fun way (Damayanti et al., 2024; Reinita et al., 2023). The latest in this study, the integration of comic interactive into the PBL model, is expected to overcome implementation barriers while increasing student involvement in learning. In line with the following Figure 1, the bibliometric analysis results are shown.

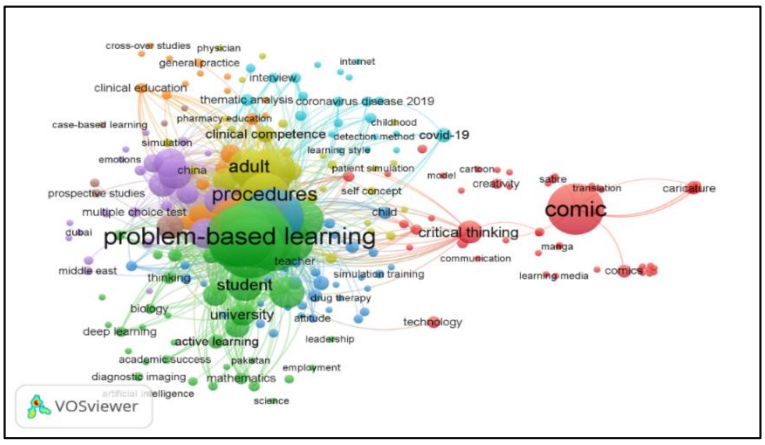

Figure 1. PBL Networking, Critical Thinking, and Comic Trends in Research in the Last 5 Years

Figure 1 shows that the VOSviewer mapping of 357 research articles over the last five years highlights a research gap between the dominance of procedural Problem-Based Learning and the continued positioning of comics as complementary media. The interactive, comic-based PBL model offers a systematic pedagogical integration that stimulates elementary school students' critical thinking in a contextual and meaningful way.

Based on the description above, this research focuses on developing an interactive, comic-based PBL model to improve elementary school students' critical thinking skills. This research is

designed to answer two main problem formulations, namely: (1) What is the feasibility and practicality of the comic interactive-based PBL model in elementary school learning? and (2) How effective is the model in improving students' critical thinking skills? In the end, this research is expected to make theoretical and practical contributions to the development of innovative learning strategies that meet the demands of the Industrial Revolution 5.0 era.

METHOD

This research is of the Research and Development (R&D) type using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model. The purpose of the research is to improve students' critical thinking skills through the development of an interactive, comic-based PBL that is feasible and practical to use. The research subjects were 30 grade V students from Elementray School 9 Sila, Bima Regency, selected using purposive sampling. The research instruments included a feasibility questionnaire filled out by material experts, media, and test instruments. Next, a practicality questionnaire was completed by teachers and students. Finally, there was a critical thinking skills test based on indicators of reflective attitude, problem-solving, analysis, evaluation, and decision-making. A total of 11 questions on critical thinking skills will undergo validity testing before the test.

The research procedure includes five stages of the ADDIE model. The analysis stage aims to identify students' characteristics and learning needs. More is related to teachers' perceptions of the application of learning with modern models and media, or, generally, to identifying research problems, followed by the design stage, which aims to describe the initial design of the developed learning product. This development product is intended as a solution or follow-up to the results of the previous analysis stage. Next is the development stage, aiming to develop or compile a development product, which is then tested for feasibility validation and empirical validity, followed by the implementation stage of the development products into the research class. The last is the evaluation stage, which assesses the results of applying development products and whether they address the research problems faced.

As a result of the above research procedure, the research will have qualitative and quantitative data. Qualitative data is obtained from product feasibility and practicality validation questionnaires. Qualitative data consist of teachers' perceptions of students' critical thinking skills and the use of modern learning models and media. Qualitative data also consists of expert interpretations of validation scores for the feasibility and practicality of development products. In contrast to quantitative data, it is obtained through empirical validity tests and pretest-posttest scores of students' critical thinking skills.

The results of this qualitative data were analysed in the form of a statement and described in the introduction. In contrast to quantitative data in the form of test scores, validity test scores, question items, and pre- and posttest scores of students' critical thinking skills. This data was analysed using SPSS 24, including n-gain score tests and a one-way ANOVA, to assess the effectiveness of the comic-based interactive PBL model. Then, using the Ministep software (Rasch Model), we can determine the disruption to students' grades.

RESULT AND DISCUSSION

Results

The study's results include three main aspects: product feasibility, practicality, and effectiveness. Previously, a brief description of the product was presented. This research produced an interactive, problem-based learning model product designed specifically for elementary school students. This model follows the PBL syntax, which includes problem orientation through contextual interactive comics, student organisation in understanding problems, independent investigation and analytical activity-based groups, development and presentation of solutions, and analysis and evaluation of problem-solving processes. The integration of interactive comics serves as a visual-narrative lighter, strengthening students' cognitive engagement and critical thinking. Comic

interaction facilitates students' cognitive engagement through narrative, dialogue, and interaction, thereby supporting the analysis, evaluation, and reflection that develop critical thinking skills. The description of the comic products produced is shown in Figure 2.

Figure 2. Examples of Comic Interactive Products Produced

Product Eligibility

Three (3) Experts in materials, media, and test instruments have validated the product before it is applied in class. The results are presented in Table 1.

Table 1. Product Eligibility

Learning Products	Assessment Aspects	Validator Score			Average	Category
		I	II	III		
PBL Model (RPP)	Model Fit				3.67	Worthy
	Compatibility of the model with the learning objectives and the Merdeka curriculum	4	4	3		
	Syntax compatibility	4	4	4		
	Relevance of contextual issues	3	4	3		
	Supporting the development of students' critical thinking skills	3	4	4		
	Material Eligibility					
	Compatibility of the material with the syntax	3	3	4		
	Clarity of material in interactive comics	4	3	3		
	Accuracy of material concepts for elementary school students	4	4	4		
	Material compatibility with KD and CP	4	3	4		
	Solid material with a comic interactive	3	4	4		
Comic Interactive	The attractiveness of media design for elementary school students	4	3	4	3.86	Highly Worth It
	Clarity of media usage indicators	4	4	4		
	Visual quality of media	4	4	4		
	The concept of media can present student interactivity	4	4	4		
	Use of language or sentences that are easy for elementary school students to understand	3	4	4		
Critical Thinking Skills Test	Compatibility with critical thinking indicators	4	4	4	3.83	Highly Worth It
	Measuring the appropriate material on interactive comic media	4	4	3		
	Match the score to the difficulty level of the item	4	4	4		
	Compatibility with the time and materials of elementary school students	3	4	4		

Referring to Table 1, the products developed for the PBL (90.8%), comic interactive (96.5%), and critical thinking skills test (95.7%) have been suitable for use. Critical thinking skills tests were also administered to 30 grade VI students to assess the validity of the 11 questions. The results are shown in Table 2.

Table 2. Results of the Validity Test of the Critical Thinking Skills Test

No.	Table Value (5%)	Calculated r Value	Verdict
1	0.306	0.322	Valid
2		0.365	
3		0.431	
4		0.546	
5		0.352	
6		0.646	
7		0.467	
8		0.336	
9		0.618	
10		0.697	
11		0.688	

All Question items were tested on 30 grade VI students, yielding a table R value of 0.306. The score acquisition (r calculated > 0.306) indicated that all the questions developed were valid and could be used to measure students' critical thinking skills.

Product Practicality

Teacher and student responses to the application of interactive comics and critical thinking skills tests are needed to determine the practicality of the research products used in learning. The results are shown in Table 3.

Table 3. Product Practicality

Learning Products	Observation Aspect	Respondent Score (Teacher)			Average	Category
		I	II	III		
Comic Interactive	Students are interested and motivated in learning	4	4	4	3.73	Very Practical
	Students easily use the media without any mistakes	3	4	4		
	The media looks clear and attractive	4	3	3		
	The learning process is more interactive with these media	4	4	4		
	Students can absorb information well in the media	4	4	3		
		Respondent Score (Student)			**Average**	**Category**
		I	II	III		
Critical Thinking Skills Test	Questions according to the material studied before	4	4	4	3.91	Very Practical
	Question scores according to their difficulty					
	Provision of appropriate processing time					
	Clear and precise question instructions					

The results of the product practice. The literature test (Table 3) shows that comic interaction (93.25%) is highly practical for elementary school students' learning. Likewise, the critical thinking skill test (97.75%) is highly practical for assessing critical thinking skills in elementary school students.

Product Effectiveness

The development product will ultimately be evaluated for its impact on students' critical thinking skills. For each critical thinking skill indicator, results are shown in Figure 3.

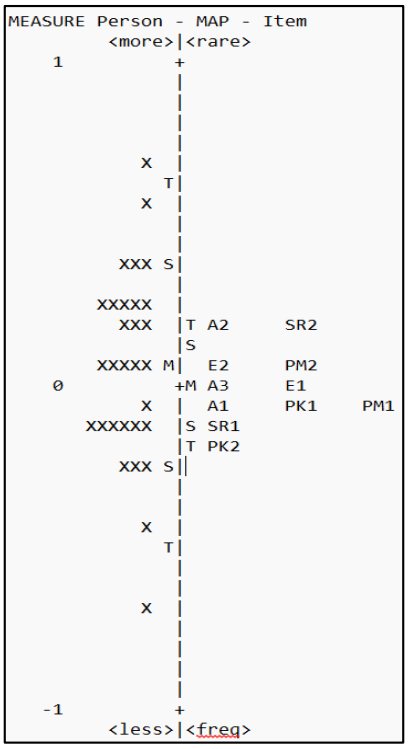

Figure 3. Difficulty Level of Critical Thinking Skills Indicator

Based on Figure 3, the decision-making indicator (PK2) is the easiest for students to answer or achieve. Meanwhile, the analysis indicator (A2) is the most difficult for students to answer or achieve. Unique achievements in reflective attitudes (SR1 and SR2) include relatively moderate question indicators: some students can answer them easily, while others are unable or have difficulty doing so.

The results of the rush analysis of the model above are supported by the n-gain score analysis based on students' pre- and posttest scores for critical thinking skills. The following is presented in Table 4.

Table 4. Pretest and Posttest Results per Indicator

No.	Indicator	Pretest Experiments	Posttest Experiment	N-gain Experiment
1	Reflective Cap	58.50	81.52	0.59
2	Troubleshooting	58.14	84.43	0.67
3	Analysis	58.09	80.35	0.58
4	Evaluation	56.51	80.01	0.60
5	Decision Making	55.89	87.03	0.72

The results of the n-gain score test (Table 4) show that each indicator increased, generally indicating the effectiveness of students' critical thinking skills through the application of development products in the form of interactive, comic-based PBL models. Specifically, the decision-making indicator (PK) is in the high-effectiveness category (72%) due to the application of development products. In contrast, the other four indicators (reflective attitude, problem-solving, analysis, and evaluation) are in the moderate effectiveness category (<70%) due to the implementation of development products.

Furthermore, the achievement curve for the question indicator will be traced for each student to show differences in students' critical thinking skills across indicators. As shown in Figure 4.

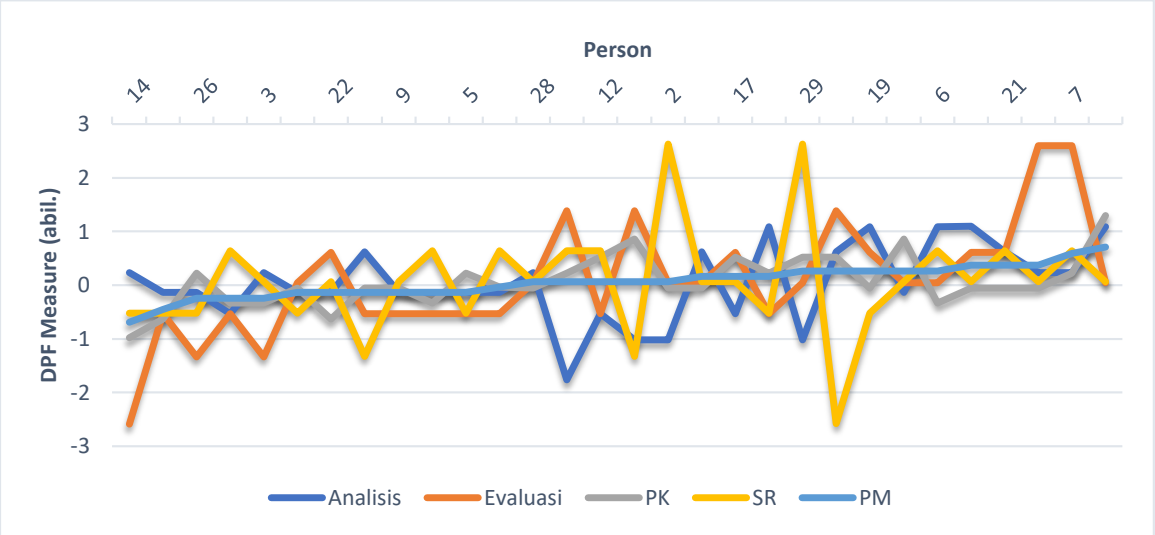

Figure 4. Achievement Curve of Question Indicators

Figure 4 shows that student achievement scores across indicators vary. This achievement indicates that students have different critical thinking skills across the indicators. For example, student number 22 has the highest critical thinking skills on the analysis indicator and the lowest on the reflective attitude indicator. Inversely proportional to student number 29, the maximum on the reflective attitude indicator, and the minimum on the analysis indicator.

When reviewing each indicator, determine whether there is a difference in students' critical thinking skills between pre- and posttest scores. Referring to Table 4, each question indicator has increased, indicating the effectiveness of the interactive comic-based PBL model. It is also necessary to know whether, overall, based on the pre-post test score, there is a difference in students' critical thinking skills. The results are presented in Tables 5 and 6.

Table 5. Results of the Paired Sample Test of Students' Critical Thinking Skills

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Hours of deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Post Test of Critical Thinking Skills - Pre Test of Critical Thinking Skills	4.13333	2.73840	.49996	3.11080	5.15587	8.267	29	.000

The results of the paired-samples t-test (Table 5) showed that there was a difference (sig < 0.05) in students' critical thinking skills scores before (pretest) and after (posttest) learning with the comic-based interactive PBL model.

Table 6. Results of the n-Gain Score Test, Pre-post Test, and Critical Thinking Skills

Pretest (Mean ± SD)	Posttest (Mean ± SD)	N-Gain	Category	
64.20 ± 2.24	92.96 ± 2.85	0.74	Height	The results of the paired-samples t-test (Table 5) showed that there was a difference (sig < 0.05) in students' critical thinking skills scores before (pretest) and after (posttest) learning with the comic-based interactive PBL model.

The results in Table 6 indicate that the comic-based interactive PBL model is highly effective (0.74) in improving students' critical thinking skills.

Discussion

Product Qualification in Theoretical and Research Perspectives

The validation results from material and media experts, with a feasibility score of 91.25%, placed this interactive PBL model in the "very feasible" category. This value indicates that, in terms of content, learning flow, and media quality, the product meets innovative learning quality standards. In the context of learning design theory, this success can be attributed to the consistent application of the ADDIE framework. The analysis stage ensures it is suitable for elementary school students (Haifaturrahmah et al., 2020; Muhammad et al., 2025). Design and Development produces media that is in accordance with Mayer's multimedia learning principles, such as the principles of Kuba et al., (2021) of dual coding (the combination of text and images), coherence (avoiding redundant information), and contiguity (placement of text near visuals).

Empirically, this feasibility achievement is in line with research by Matuk et al., (2021), which confirms that comic-based media can increase student engagement if designed with the cognitive and affective aspects of students in mind. In their study, comic media that feature clear narrative flow, interesting illustrations, and relevance to students' lives have been shown to improve understanding of science concepts at the elementary school level. The products produced in this study adopt a similar strategy, namely, presenting problems in the form of contextual visual narratives.

From a curriculum perspective, this feasibility can also be linked to the expected learning outcomes in the Independent Curriculum. This medium not only channels information but also facilitates students' understanding through interactive learning experiences. As one of the products that integrates PBL and interactive comics, the high feasibility demonstrates that proper instructional design can produce media that is not only visually appealing but also has significant pedagogical power.

Product Practicality and Relevance in a Real Classroom

The product's practicality, as measured by teachers and students at 89.50%, shows that this model is easy to use in the classroom without requiring excessive adaptation. Practicality for teachers lies in the availability of clear user guides and learning syntax, so that the implementation process can run as planned without requiring intensive training. This supports the principle of teacher-friendly innovation, which emphasises the importance of learning innovations that can be integrated into teachers' routines without significantly increasing the workload (Hu & Shen, 2024; Shuhaimi et al., 2025).

For students, the ease of access and navigation in the comic interface provides space for self-directed learning. In line with the theory of self-regulated learning, Students who have control over their learning process will be more motivated and responsible for their achievements. Research by Al-Shaye (2021) also found that digital narrative-based learning media can improve students' emotional and cognitive engagement, as they allow students to set their own learning pace and explore material according to their interests.

The students' positive response to this product also shows that comic-based interactive media can embrace a variety of learning styles. Visual and narrative texts support visual and verbal learners. At the same time, interactive elements stimulate kinesthetic learners. This suitability supports Gardner's theory of multiple intelligences, which emphasises that effective learning requires varied experiences to accommodate differences in students' learning styles (Annamalai et al., 2025).

Product Effectiveness in Improving Critical Thinking Skills

The effectiveness of the comic-based interactive PBL model is evident from the average n-gain value of 0.74 (high category) in the experimental class. This increase indicates a transfer of skills from problem-based learning activities to students' critical thinking skills. Indicators such as analysis and evaluation showed the greatest improvement, indicating that students not only understood the material but also assessed and verified the validity of the information they were dealing with.

Theoretically, these findings are consistent with the constructivist learning framework, which positions students as active subjects in the construction of knowledge (Azzahra et al., 2025;

O'Connor, 2022). PBL facilitates the process by directing students to explore problems, formulate hypotheses, seek information, and test solutions. Research from Setyawan & Koeswanti (2021) in elementary school students also showed that PBL significantly improved critical thinking skills, especially when combined with supporting media that motivated students to be actively involved.

Another source of support comes from the results of a one-way ANOVA, which show significant differences between the experimental and control classes, reinforcing the argument that the improvement in critical thinking skills is not the result of chance or external factors but a direct effect of the application of this model. This is in line with the findings Palvia et al., (2023) which states that the integration of problem-solving skills in learning has a causal effect on the improvement of critical thinking skills, especially on indicators of logical analysis and decision making.

Integration with the Independent Curriculum and 21st Century Skills

The comic-based interactive PBL model developed is highly relevant to the implementation of the Independent Curriculum, which focuses on in-depth, meaningful, mindful, and joyful learning. The meaningful learning aspect is achieved because students are faced with real problems in their lives, so the material learned becomes relevant and easy to remember.

In terms of mindful learning, this medium provides students with the opportunity to reflect on every decision taken during the problem-solving process. Visual narratives in interactive comics present scenarios that encourage students to consider the consequences of each action, aligning with the critical thinking indicators of "reflective attitude" and "decision-making". This approach aligns with Dewey's theory of reflective thinking, which holds that effective learning occurs when students relate new knowledge to their experiences through reflection.

The joyful learning component is evident in students' responses, who feel that learning becomes more interesting and less boring. Visual and interactive elements create a learning atmosphere that resembles an educational game, which can lower psychological barriers to learning (e.g., learning anxiety) and increase intrinsic motivation. These findings are consistent with the results of the study by Reinita et al., (2023), which states that digital comics in PBL can increase learning motivation through increased student engagement.

Theoretical and Practical Implications

Theoretically, this research contributes to the literature on 21st-century learning innovations, particularly by integrating PBL models with interactive digital media. The resulting product demonstrates that combining problem-based pedagogical strategies with learning technology can lead to significant improvements in critical thinking skills (Maquiling & Desabella, 2025; Pavitola & Rieksta, 2025). This model can serve as a reference for developing other learning media focused on higher-order thinking skills (HOTS).

In practice, this model has great potential for widespread implementation in elementary schools, especially in areas that have adopted the Independent Curriculum. Teachers can adapt interactive comic content according to other subjects such as science, social studies, or Indonesian (Pramulia et al., 2025; Rajan & Wei, 2025). The product's practicality makes it easy for teachers to integrate into the lesson plan without complicated training, while students can use it independently outside formal lesson hours.

In addition, given that critical thinking skills are among the core competencies outlined in the vision of a Golden Indonesia 2045, the application of this model directly contributes to achieving national education goals. With further development, comic interactive can also be integrated with gamification or augmented reality features to improve interactivity and learning effectiveness.

CONCLUSION

The resulting development products are the comic interactive PBL model and the critical thinking skills test, which have been suitable for use. After implementation, the comic-based interactive PBL model and the critical thinking skills test are highly practical for assessing elementary school students' critical thinking skills. The application of development products can improve students' critical thinking skills. Specifically, the decision-making indicators (PK) are in the

high-effectiveness category due to this application. In contrast, the other four indicators (reflective attitude (SR), problem solving (PM), analysis (A), and evaluation (E)) are in the medium effectiveness category due to the application of development products. In general, there are differences in students' critical thinking skills before and after applying the PBL model through comic interaction. The test-n-gain score shows an increase in students' critical thinking skills, placing them in the high category.

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