

Effectiveness Of Problem Based Learning Supported by Interactive Multimedia And Digital Simulation on Critical Thinking Skills

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Abstract

This study aims to determine the effectiveness of problem-based learning supported by interactive multimedia and digital simulation on critical thinking skills. This is a quantitative quasi-experimental study, with a pretest-posttest non-equivalent group design. The population consisted of 431 tenth-grade students at SMA N 3 Semarang, and the sample consisted of 72 students. The sampling technique used was purposive sampling. Data collection methods included pretest and posttest, student questionnaires that had been tested for validity using SPSS Version 31, and observation sheets. Data analysis methods included descriptive statistical analysis, independent sample t-test, and N-Gain test. The results showed that the use of PBL assisted by digital simulation was more effective than the use of PBL assisted by interactive multimedia. This was seen from the average posttest results in the experimental class, which was 79.03, while in the control class it was 74.22. Then, the N-Gain test score for the control class was 49.94 or 50%, which was categorized as ineffective. Meanwhile, the N-Gain of the experimental class was 61.50 or 62%, which is classified as moderately effective. Researchers are expected to further expand the learning model used according to needs and conditions and select learning media that are interesting but also suitable for learning activities.

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INTRODUCTION

In the era of industrial revolution, challenges in education continue to grow along with increasingly complex societies and rapidly developing technology. The education system is required to develop a framework that emphasizes mastery of competencies, understanding of material, and character relevant to success in the 21st century (Martinez, 2022). Therefore, learning must continue to evolve in line with the developments and needs of the times. Saastamoinen et al. (2023) state that schools have an important role in preparing students to face the challenges and opportunities of the future. Schools are required to produce graduates with 21st-century skills, which are necessary for success in the workplace and society. Learning in the 21st century is characterized by the integration of 21st-century skills into learning. One of these skills is learning and innovation skills, which include the 4Cs: communication, collaboration, critical thinking, and creativity (Sukmawati & Ghofur, 2023). Among the 4C skills, critical thinking is one of the most important skills in developing 21st-century skills.

Almulla (2023) states that critical thinking is an important intermediary between problem solving and other 21st-century skills. In the context of problem-solving abilities and other 21st-century skills, such as algorithmic thinking, creativity, digital literacy, and effective communication, they are closely interrelated through collaboration and the application of critical thinking. According to Reynders et al. (2020), critical thinking is an active and purposeful process of processing information, including analyzing, evaluating, or synthesizing relevant information to achieve a deep understanding and make informed decisions based on evidence. In learning activities, critical thinking skills are necessary for students to process information and solve problems in learning. Critical thinking is a key element that is very important in the teaching process at all levels (Pramudita et al., 2023).

The level of critical thinking skills among students in Indonesia can be seen based on the results of the Programme for International Student Assessment (PISA) test. The types of questions on the PISA test are HOTS (Higher Order Thinking Skills) standard questions that can encourage students' critical thinking skills. Based on the results of the 2000-2002 PISA test, Indonesia has always ranked at the bottom of the participating countries. In 2022, Indonesia ranked 68th out of 81 countries that took the test. In the context of Indonesian education, understanding students' critical thinking skills is crucial. Therefore, developing students' critical thinking skills is a very important effort in determining the quality of education and the readiness of students to face global challenges (Eka & Budiarti, 2023).

SMA N 3 Semarang is one of the leading high schools in the city of Semarang. Students in the 10th grade at SMA N 3 Semarang are actively engaged in the learning process and demonstrate a good level of conceptual understanding of the material they have studied. According to teachers, learning assessments already use Higher Order Thinking Skills (HOTS) questions. However, some students still have difficulty analyzing

and solving these questions, so they are often confused in choosing the right answers. One of the reasons for this difficulty is that students are not accustomed to dealing with HOTS-based questions. This condition reflects that the development of students' critical thinking skills still faces various challenges, especially in the context of economics learning. Therefore, more focused and innovative efforts are needed in designing a learning process that can stimulate students' critical thinking skills in a sustainable manner.

One effort to overcome this problem is to use an appropriate learning approach, which can take the form of models and media. The selection of relevant and appropriate learning models plays an important role in attracting students and encouraging their participation in developing their critical thinking skills (Islami & Soekamto, 2022). This study will use the PBL model because it is considered appropriate and relevant to the needs and problems experienced by 10th grade students at SMA N 3 Semarang, namely developing students' critical thinking skills by solving complex problems in everyday life related to economics. The PBL model has the advantage of improving problem-solving skills, conceptual understanding, critical thinking skills, and achieving desired learning outcomes (Kurniawan et al., 2023). PBL is one method that plays a role in developing critical thinking skills and helps students master skills such as problem-solving and higher-order or critical thinking skills (Koçoglu & Kanadl, 2025). According to Sastradewi & Agung (2022), multimedia can guide students with high reasoning skills through problems that must be solved, thereby making the learning process meaningful and motivating students to learn. Another type of media is simulation media, which makes learning more meaningful and memorable, helps students understand concepts better, develops critical thinking skills, and improves overall learning outcomes. In their research, Ridwan & Kembuan (2021) also stated that the use of simulation media in learning can improve students' critical thinking skills. Simulation learning encourages students to be actively and freely involved in experimenting with new things.

Previous studies have examined the effectiveness of innovative models and learning media on critical thinking skills. For example, Islami & Soekamto (2022) used an inquiry learning model with Quizziz multimedia. Aprilia (2021) research utilised the Science Flipbook medium. Kiranadewi & Hardini (2021) used a combination of Problem-Based Learning and Problem Solving, while Wulandari et al. (2022) employed a guided inquiry learning model assisted by PowerPoint media. Then, Mutiara et al (2023) used a PBL model assisted by Macromedia Flash, Ningtias et al. (2024) used a PBL model assisted by audio-visual media, and Agustina et al. (2024) used a combination of PjBL assisted by Phet simulations. Based on previous research, there have not been many studies comparing the effectiveness of models and media on critical thinking skills.

This study has a novelty from previous studies, namely the Problem-Based Learning (PBL) model combined with interactive multimedia and digital simulation media, which will later be compared in terms of their effectiveness on students' critical thinking skills. According to Maunino & Tacoh (2023), the development of students' critical thinking skills can be optimised with the help of technology-based learning media, especially media that allows students to think and respond to learning. Therefore, this study aims to analyze in depth and compare the effectiveness of the multimedia-assisted Problem-Based Learning

(PBL) model and digital simulation in economics lessons on the critical thinking skills of 10th grade students at SMA N 3 Semarang.

METHODS

This study used a quantitative approach and a quasi-experimental research design, with a pretest-posttest non-equivalent group design. The population in this study consisted of 431 students in grade X at SMA Negeri 3 Semarang, comprising classes X-1 to X-12. In this study, the sampling technique used was purposive sampling. Purposive sampling is a sampling technique with a specific purpose or consideration. The considerations in this study were (1) the samples were at the same level; (2) the samples were taught by the same teacher; (3) the samples assigned to the control and experimental classes were equal in number; and (4) the samples had the same average summative score in economics. Based on these considerations, the classes that met the requirements were class X-9 with 36 students as the control class and class X-10 with 36 students as the experimental class.

Data collection techniques used pre-tests and post-tests, student questionnaires that had been tested for validity using SPSS Version 31, and observation sheets. Data analysis methods used descriptive statistical analysis, independent sample t-tests, and N-Gain tests using the SPSS version 31 program. The pretest-posttest questions are HOTS questions in essay form, consisting of 8 questions, comprising 2 interpretation questions, 2 analysis questions, 2 evaluation questions, and 2 inference questions. This composition is in accordance with the critical thinking ability indicators used in this study, namely the indicators presented by Sun (2026). These four indicators are core skills centred on the reasoning process in argumentation.

RESULT AND DISCUSSION

RESULT

Descriptive Analysis

The results of statistical analysis of pretest and posttest data in the experimental class and control class are as follows.

Table 1. Descriptive Analysis Results

	Descriptive Statistics					
	N	Range	Minimum	Maximum	Mean	Std. Deviation
Pretest Kontrol	36	50	25	75	45.11	12.819
Posttest Kontrol	36	38	58	96	74.22	9.997
Pretest Eksperimen	36	42	21	63	44.22	9.178
Posttest Eksperimen	36	37	63	100	79.03	8.752
Valid N (listwise)	36					

Source: Research data processed by researchers (2026)

Based on the data in Table 1, descriptive analysis of the control class and experimental class shows a difference in the average results of students' critical thinking

skills in economics between the control class and the experimental class. The average pretest score for the control class was 45.11 and for the experimental class was 44.22, while the average posttest score for the control class was 74.22 and for the experimental class was 79.03. Based on these results, it can be concluded that there is a difference in the average scores between the control class and the experimental class.

Normality Test

The results of the normality test for the pretest and posttest data in the control and experimental classes are presented in the following table:

Table 2. Normality Test Result

Result	Class	Tests of Normality					
		Kolmogorov-Smirnov ^a			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Result	Pretest Control	.105	36	.200*	.947	36	.082
	Posttest Control	.126	36	.157	.955	36	.148
	Pretest Experiment	.110	36	.200*	.976	36	.597
	Posttest Experiment	.119	36	.200*	.961	36	.236

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Source: Research data processed by researchers (2026)

Based on Table 2, the sig value for the control class was 0.082 on the pretest and 0.148 on the posttest, which means that both show normally distributed data because they are greater than 0.05. Then, in the experimental class, the sig value in the pretest is 0.597 and, in the post-tests, it is 0.236, which means that the data is also normally distributed because both have a sig value greater than 0.05. It can be concluded that both classes, experimental and control, are normally distributed in the pretest and posttest.

Homogeneity Test

The results of the homogeneity test for this study are presented in the following table:

Table 3. Homogeneity Test Result

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Grade	Based on Mean	.534	1	70	.467
	Based on Median	.525	1	70	.471
	Based on Median and with adjusted df	.525	1	68.349	.471
	Based on trimmed mean	.526	1	70	.471

Source: Research data processed by researchers (2026)

Based on Table 3, it was found that the sig Based on Mean value was 0.467, which means that the sig Based on Mean value was greater than 0.05. Therefore, the variance in the pretest and posttest of the experimental class and the control class was homogeneous or had the same variance, so one of the (non-absolute) requirements for the independent sample t-test was met.

Independent Sample T-Test

The Independent Sample T-Test was conducted using posttest data from the control and experimental classes in this study, processed using SPSS version 31. The results of the Independent Sample T-Test are presented in the following table:

Table 4. Independent Samples Test Result

Independent Samples Test									
t-test for Equality of Means									
Nilai		t	df	Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
				One-Sided p	Two-Sided p			Lower	Upper
	Equal variances assumed	-2.170	70	.017	.033	-4.806	2.215	-9.222	-.389
	Equal variances not assumed	-2.170	68.797	.017	.033	-4.806	2.215	-9.224	-.387

Source: Research data processed by researchers (2026)

Based on Table 4, the results of the independent sample t-test show that the Sig. (2-tailed) value is 0.033, so it can be concluded that there is a difference in the average critical thinking skills of students in the experimental class who used the Problem-Based Learning model assisted by digital simulations and the control class who used the interactive multimedia-based Problem-Based Learning model because the Sig. (2-tailed) value of $0.033 < 0.05$.

N-Gain Test for Control Class and Experimental Class

The results of the N-Gain test for the pre-test and post-test scores of the experimental class and control class are presented in the following table:

Table 5. N-Gain Test Results for Control Class and Experimental Class

Class	Average Score		N-Gain Score	Interpretation	N-Gain Persen	Interpretation
	Pretest	Posttest				
Control	45,02	74,19	0,499	Moderate	49,94%	Less Effective
Experimental	44,10	78,94	0,615	Moderate	61,50%	Quite Effective

Source: Research data processed by researchers (2026)

Based on Table 5, the N-Gain test results show that the average N-Gain value in the control class, which is the class with the interactive multimedia-assisted PBL model, is 49.94 or rounded to 50% in percentage form, which is included in the less effective category. This shows that the use of the interactive multimedia-assisted PBL model is less effective in improving students' critical thinking skills in economics. Meanwhile, in the experimental class, which used the PBL model assisted by digital simulation, the N-Gain score was 61.50, rounded to 62% in percentage form, which falls into the fairly effective category. This shows that the use of the PBL model assisted by digital simulation is fairly effective in improving students' critical thinking skills in economics.

DISCUSSION

Analysis of the Development of Students' Critical Thinking Skills

The critical thinking skills of 10th grade students at SMA Negeri 3 Semarang showed a positive trend after being given treatment in the form of a PBL learning model assisted by interactive multimedia and digital simulation media. This was evident in the learning process, where students actively expressed their opinions and discussed while working on case studies. This process reflects the students' ability to interpret economic problems, analyze cause-and-effect relationships, evaluate alternative solutions, and draw conclusions based on available data and information. Based on the results of data processing using SPSS version 31, presented in the descriptive analysis in Table 1, there was an increase in pretest and posttest scores in each class.

This is in line with the characteristics of the test instrument used, namely HOTS questions in the form of descriptions that require students not only to remember concepts but also to explain reasons, provide assessments, and construct logical arguments. These questions are in line with the critical thinking ability indicators used in this study, namely the critical thinking ability indicators according to Sun (2026) which include interpretation, analysis, evaluation, and inference.

The Control Class uses an interactive multimedia-assisted PBL model, with case studies presented in the form of news videos containing current economic issues, and each group receives a different news video. Students are asked to analyze the issues presented in the news videos, then discuss them to identify the problems and formulate appropriate solutions. When working on case studies, each group member has their own task, with some students acting as problem observers, cause analysts, supporting data seekers, solution proposers, solution evaluators, and conclusion makers. Although there is a specific division of tasks, each role is interrelated. Therefore, each group needs to discuss to complete the case study.

The results of the observation show that each group member works together to complete the case study, but the discussion is considered to be lacking because each group member focuses on their own tasks. Next, each group presented their findings. Based on the observations, students were generally able to interpret the content of the news and identify the main issues presented. However, in the analysis and evaluation stages, some students still tended to give general and descriptive answers, which were not fully supported by in-depth reasoning.

In the experimental class, learning uses PBL assisted by digital simulations. The experimental class uses case studies presented in the form of story questions that require students to play the role of certain economic actors. Each group member has a different role and task, so students must collaborate in analyzing problems and determining the most appropriate solutions. In addition, the roles assigned are interrelated, encouraging students to work together and engage in discussions to complete the case studies.

Observations show that through these role-playing simulation activities, students are more active in expressing their opinions, considering various alternative solutions, and evaluating the impact of the decisions made. This process encourages students to think analytically and inferentially, especially when they have to agree on the final solution for the group. After the discussion is complete, each class presents the results of their discussion. At this stage, it is not only the presenting group that actively expresses their opinions. Members of other groups also actively respond to the results of the group discussions that have been presented. As a result, the class discussion runs more optimally and is two-way.

The pretest and posttest results for the control and experimental classes showed improvement. The control class, which used a multimedia-supported Problem-Based Learning (PBL) model, obtained an average pretest score of 45.11 and an average posttest score of 74.22. Meanwhile, the experimental class, which used a PBL model supported by digital simulations, obtained an average pretest score of 44.22 and an average posttest score of 79.03.

Based on the results of the pretest and posttest, both the control class and the experimental class showed an increase in students' critical thinking skills after participating in the learning process. Thus, the learning process applied in both classes using the PBL model assisted by interactive multimedia and digital simulations was able to encourage the development of students' critical thinking skills, despite the different characteristics of the learning process. Research conducted by Yani & Santoso (2024) shows that combining learning models with interactive multimedia can help students gain understanding in learning activities and improve their critical thinking skills. The digital simulation media in this study is role-playing based using digital media. According to Purasani et al. (2025), using this media makes learning more collaborative, with students taking turns playing their respective roles. This approach facilitates the process of exchanging ideas within the group and provides a meaningful learning experience.

This is in line with research Noviyanti et al., (2024) showing that the application of the PBL model assisted by interactive learning media can improve students' critical thinking skills. The research Mailestari et al., (2024) applied the PBL model assisted by interactive PowerPoint media, which was effective in improving students' critical thinking skills. Furthermore, the study Sari et al., (2025) used a PBL model assisted by digital media that influenced students' critical thinking skills and learning outcomes. The study Utami et al., (2025) showed that the application of a PBL model assisted by interactive media such as Educaplay can be an effective alternative to improve critical thinking skills. The study Rahmadani & Yulhendri (2022) applied role-playing learning, which had a significant effect on students' critical thinking skills. The study Agustina et al. (2024) applied the PBL model assisted by PhET simulations, which influenced students' scientific attitudes and critical thinking skills. Furthermore, the study Amalia et al., (2022) stated that the use of the PjBL model assisted by PhET simulations could influence students' critical thinking skills.

Comparison of Media Effectiveness on Students' Critical Thinking Skills

Based on the results of the N-Gain Test in the control class presented in Table 3, an N-Gain Score of 0.499 was obtained, which means that the increase in critical thinking skills was in the moderate category. Meanwhile, the N-Gain Percentage result was 49.94, rounded to 50%. According to Hake, R.R (1999), this value indicates that the use of interactive multimedia has a less effective impact on improving students' critical thinking skills. Based on the results of the student questionnaire regarding the use of interactive multimedia, out of 36 students, 4 students gave very positive responses on average, 26 students gave positive responses on average, and the remaining 6 students gave fairly positive responses on average regarding the use of media. These values indicate that most students responded positively to the use of the PBL model assisted by interactive multimedia in learning to develop their critical thinking skills.

Problem-based learning supported by interactive multimedia in this study is in line with constructivist theory, which emphasises that knowledge is actively constructed by students through meaningful learning experiences. Sioukas (2023) explains that Constructivism emphasises a learning process that transforms initial understanding into knowledge that is formed independently or through collaboration with other people and groups. Apoko & Waluyo (2025) state that 'Constructivism emphasises the active role of learners in constructing knowledge through authentic tasks and social interaction', which means that through interaction with the environment during the learning process, students independently and actively build their cognitive understanding. Interactive multimedia in the form of videos, texts, and visual illustrations serve as cognitive stimuli that help students connect new information with their prior knowledge. Through the presentation of contextual problems, students are encouraged to interpret and analyse the economic phenomena presented. However, the knowledge constructed tends to be representational in nature, as student interaction occurs mostly at the observation and guided discussion stages, so that the development of critical thinking skills is mainly evident in the aspects of understanding problems and analysing initial information.

In the experimental class, based on the N-Gain Test results presented in Table 3, an N-Gain Score of 0.615 was obtained, which means that the increase in critical thinking skills was in the moderate category. Meanwhile, the N-Gain Percentage result was 61.50, or rounded to 62%. According to Hake, R.R (1999), this value indicates that the use of digital simulation media has a fairly effective impact on improving students' critical thinking skills.

In the student questionnaire results regarding the use of digital simulation media, out of 36 students, 16 students gave very positive responses on average, 17 students gave positive responses on average, and the remaining 3 students gave fairly positive responses on average regarding the use of the media. These values indicate that most students responded positively to the use of the PBL model assisted by digital simulation media in learning to develop their critical thinking skills.

The use of role-playing-based digital simulation media in Problem-Based Learning in experimental classes is in line with constructivist theory, which views learning as an active process of constructing knowledge through social interaction and direct experience. Sasson et al., (2018) state that 'Constructivist learning environments expose their learners to a variety of information sources, allow the processing of information into knowledge from different points of view, create a connection between the learning process and the learners' personal experience and culture, support the use of diverse learning styles and encourage reflection on the learning process'. The concept of constructivist learning environments emphasises that knowledge is not transferred directly from the teacher to the student, but is actively constructed by the student through interaction with the learning environment. According to Do et al., (2023) explained, 'According to Social Constructivism theory, students are centred, not instructors. When students actively construct their own understanding through social engagement with their peers, learning outcomes can be effective'. In this theory, learning focuses on students. Students build their understanding through interaction with their environment. Meanwhile, teachers act as facilitators who create a conducive learning environment and design learning activities.

In this simulation, each student plays a specific role according to the given economic problem context, so that students not only understand abstract concepts but also construct knowledge through actions, discussions, and decision-making. Role-playing activities encourage students to analyse problems from different perspectives, evaluate alternative solutions, and draw inferences based on the roles and responsibilities they assume. This process strengthens students' cognitive and social engagement, so that the development of critical thinking skills, particularly in terms of analysis, evaluation, and inference, is more prominent than in learning that focuses only on the presentation of information.

The following diagram shows the average increase in pretest and posttest scores for the control class and experimental class in economics lessons on the topic of Economic Problems in Economic Systems:

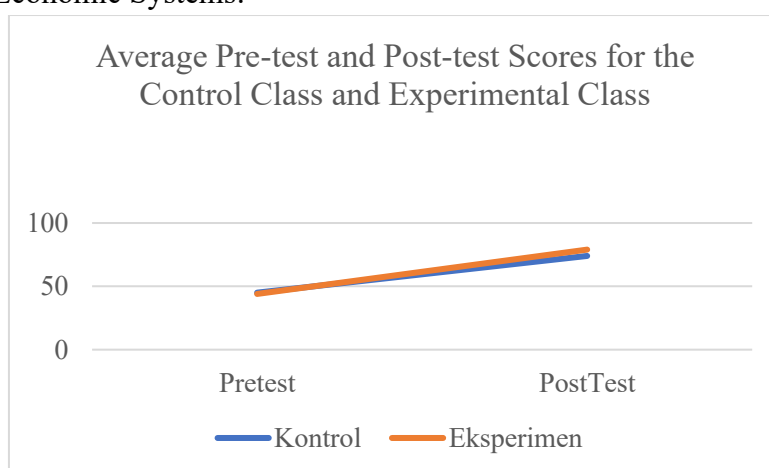


Figure 1. Comparison of Pre-test and Post-test Scores
Source: Data processed by researchers (2026)

Based on the line diagram showing the average increase in pretest and posttest scores for the control class and the experimental class, it can be seen that the initial abilities of the control class and the experimental class were almost the same, with the average pretest score for the experimental class even lower than that of the control class, namely 44.22 compared to 45.11 for the control class. After the treatment, which was Problem-Based Learning (PBL) assisted by interactive multimedia in the control class and Problem-Based Learning (PBL) assisted by digital simulation media in the experimental class, the results showed that the critical thinking skills of the experimental class students improved more than those of the control class. This was demonstrated by the increase in scores from the pretest to the posttest in the experimental class, which was 34.81, while the increase in the control class was only 29.11. Thus, the Problem-Based Learning model assisted by digital simulation media has proven to be more effective in improving students' critical thinking skills than interactive multimedia.

CONCLUSION

Based on the results of the research that has been conducted and the discussion explained in the previous chapter, it can be concluded that (1) There is a difference in the critical thinking skills of students in both the control class and the experimental class before and after being given treatment. The control class, which used the multimedia-assisted Problem-Based Learning (PBL) model, obtained a pretest average score of 45.11 and a posttest average score of 74.22. Meanwhile, the experimental class, which used the digital simulation-assisted PBL model, obtained a pretest average score of 44.22 and a posttest average score of 79.03. (2) Learning with the Problem-Based Learning (PBL) model assisted by digital simulation media was more effective than learning with the Problem-Based Learning (PBL) model assisted by interactive multimedia in terms of the critical thinking skills of grade X students on the subject of Economic Problems in the Economic System. This effectiveness was proven by the difference in the average pretest and posttest results of the experimental class and the control class, with the average posttest results in the experimental class being 79.03 and in the control, class being 74.22. These results indicate that the Problem-Based Learning (PBL) model assisted by digital simulation media is more effective than the Problem-Based Learning (PBL) model assisted by interactive multimedia in developing students' critical thinking skills.

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