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Improving Students' Critical Thinking Skills Using Multimedia in a Problem-Based Learning Model (PBL): a Narrative Review

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Abstract

This study explores the impact of problem-based learning (PBL) models on students' critical thinking skills, particularly those integrated with multimedia. The research reviews existing literature on the use of multimedia in PBL and evaluates its effects on student learning outcomes. Using a quantitative approach focusing on quasi-experimental designs, the study analyzes findings from multiple studies demonstrating multimedia's positive influence of multimedia, such as videos, animations, and e-books, on critical thinking. The results show that while multimedia significantly enhances student engagement and problem-solving abilities, its effectiveness is also influenced by factors such as student motivation and teacher expertise in integrating technology. However, the adoption of multimedia in PBL remains limited across educational contexts, and long-term impacts remain underexplored. The study highlights the need for further research on the long-term effects of multimedia-supported PBL and emphasizes the importance of teacher training in utilizing multimedia tools effectively. The findings suggest that expanding multimedia use in PBL could improve critical thinking skills and learning outcomes, with potential benefits for educational practices and policy development.

Keywords: Critical thinking, Digital media, Multimedia, Problem-Based Learning.

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INTRODUCTION

A required talent for addressing the challenges of the 21st-century industrial revolution is critical thinking. Students can improve their problem-solving ability and adapt to changing natural and social conditions through critical thinking skills (Indrašienė et al., 2022). Students can also enhance their academic performance and overcome problems that make them stressed so that their mental health tends to improve (Z. Liu et al., 2021). Critical thinking skills are also often used as the primary ability that is assessed to get a job (Wynekoop & Nakatani, 2024). In addition, this skill is also indispensable for managing a conflict that occurs (Li et al., 2021). Through his research, Roozenbeek et al. (2020) also revealed that a lack of critical thinking skills will spread misinformation, even fake news, that can cause public distrust of science and science. The need for critical thinking skills is a topic that is often researched, and even the use of artificial intelligence (AI) is usually associated with critical thinking skills (Cooper, 2023).

Numerous methods exist to enhance critical thinking skills, including the educational process conducted in the classroom (Karakoyun & Lindberg, 2020). Ubaidillah et al. (2023), through their research, state that a suitable learning model is needed to improve students' critical thinking skills. In addition, the interactive learning process also has a positive impact on students' critical thinking skills (Rahman & Watanobe, 2023). Tang et al. (2020) also added that collaboration between students and teachers is necessary. Through the results of his research, Sumarni & Kadarwati (2020) revealed that there is one interactive and collaborative learning model, namely the "Problem-Based Learning Model (PBL)".

"Problem-Based Learning Model (PBL)" based on self-learning (Trullàs et al., 2022). According to Rivas et al. (2022), the PBL model effectively improves students' critical thinking skills. Deng et al. (2022) also added that the PBL model is efficiently used for many fields of study. Moreover, Lee (2022) also revealed that through the use of the PBL model, students' positive attitudes and activeness in learning can increase. The increase is due to the hands-on hands-on experience offered by the PBL model (Tam, 2023).

Using multimedia or digital media in PBL can help students explore solutions and solve problems given by teachers or educators (Lozano Terrón et al., 2024). Through his research, S. Yang et al. (2024) revealed that digital media is needed to create an educational environment with an innovative and effective PBL learning model. In line with this statement, Pimdee et al. (2024) revealed that using multimedia or digital media in PBL can help improve students' critical thinking and digital skills.

The PBL model strategically improves students' critical thinking skills (Y. Liu & Pásztor, 2022). The great potential of the model attracts researchers to analyze the effectiveness of multimedia or digital media in the PBL model on students' critical thinking skills through literature studies. This literature review focuses on the problems, objectives, methods, populations, and results of previous research that examines the use of multimedia or digital media in PBL on students' critical thinking skills.

There are five research questions (RQ) that must be answered in this article, namely:

RQ1. How does the use of PBL models affect critical thinking skills?
RQ2. How does the use of multimedia in PBL affect critical thinking skills?
RQ3. What are the trends of studies regarding these three variables?
RQ4. Who are the research subjects who discuss these three variables?
RQ5. What research methods and designs are most widely used?

This research must answer each research question so that future researchers can use this article as a reference when conducting further research.

RESEARCH METHOD

The method used in this study is a literature review with a narrative approach. A literature study was conducted to find the influence of multimedia or digital media in the PBL model on students' critical thinking skills. The literature search process follows the literature criteria in Table 1. Literature search uses the "Publish or Perish" app. The literature used is only English-language articles published in reputable journals and indexed by Scopus in the last five years. The search results are analyzed using the "VOSviewer" application to explore the relationship between

each article. In addition, the "Mendeley" software is also used to organize the articles being reviewed. The review results contain information about the author's name, article title, problems behind the research, objectives, hypotheses, theories, research, population, evidence, and results. The research subjects were also analyzed based on their level of education. This literature review was conducted from September to October 2024.

Pellas et al. (2020), Jowsey et al. (2020), and Agyapong et al. (2022), through their research, they revealed that research in the field of education can be carried out using the literature review method. Elsevier introduced Scopus in 2004 as a bibliographic database in this study (Koo & Lin, 2024). Garg et al. (2024) stated that Scopus is a trusted and widely used academic database. The literature search process on the Scopus database using the "Publish or Perish" application will be carried out on October 7, 2024.

Table 1. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
• An article discusses the concept and influence of using multimedia or digital media on problem-based learning and students' critical thinking skills. • Articles in the form of research articles. • Articles from around the world. • English-language articles. • Screening is based on the search database's titles, abstracts, and keywords. • The search uses the keywords "multimedia", "digital", "problem-based learning", and "critical thinking" which are connected using the search strings "AND" and "OR". • Articles published in the last 5 years. • Article published in Scopus-indexed journal. • Articles are obtained from search results using "Publish or Perish" software.	• Articles that do not discuss the effects of multimedia or digital media use and problem-based learning on critical thinking skills. • Articles other than research articles.

Inclusion and exclusion criteria are used to obtain the best reference to be used in this review literature research. In addition, this criterion is also helpful in

ensuring that the articles that are referenced are relevant to this research and in accordance with the latest research phenomena

RESULTS AND DISCUSSION

Searching for articles in the Scopus database through the "Publish or Perish (PoP)" software obtained 200 research articles on PBL and critical thinking skills. The search results are stored as Research Information Systems (RIS). The file with the RIS extension is entered into the "VOSviewer" software to analyze the relationship between articles based on the research topic. The analysis in the software produces the visualization in Figure 1.

These two visualizations found a close relationship between PBL and critical thinking skills. Overall, it is known that the PBL model can affect students' critical thinking skills. However, multimedia or digital media use in the learning model is still not seen in visualization. This shows that there is still a low level of research or studies that reveal and discuss the influence of multimedia or digital media.

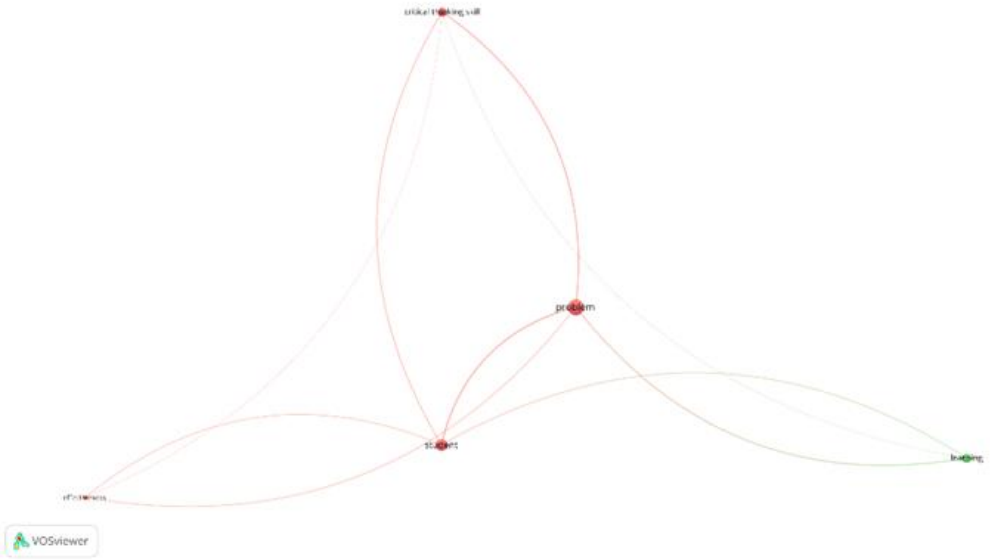

Figure 1. Visualization of Relationships Between Reference Articles (Scopus)

To get a more comprehensive connection, visualizations were also performed on the search results on the "Google Scholar" database using the same software, which resulted in the visualization in Figure 2.

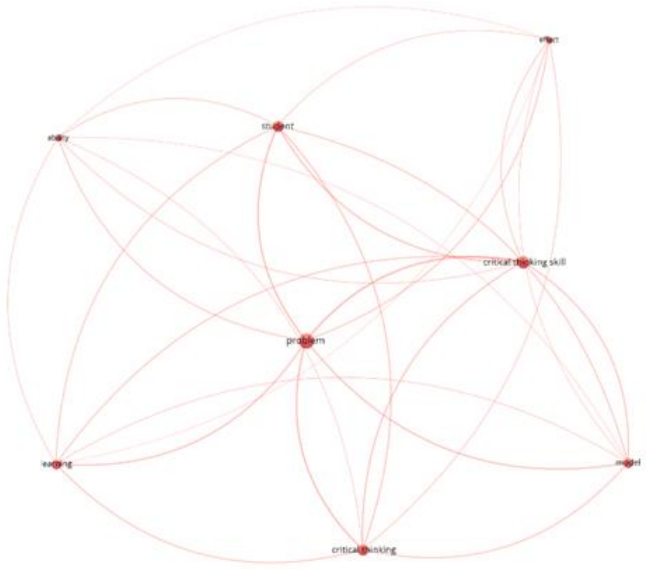

Figure 2. Visualization of Relationships Between Articles (Scholar)

The results of a literature search that discusses explicitly the influence of the use of multimedia or digital media in PBL on students' critical thinking skills and using keywords (multimedia OR "digital media" AND "problem-based learning" AND "critical thinking"), there are only 8 articles. Articles that use these keywords were published in 2020, namely 4 articles, and decreased to 1 in the following years. The research trend is visualized in Figure 3.

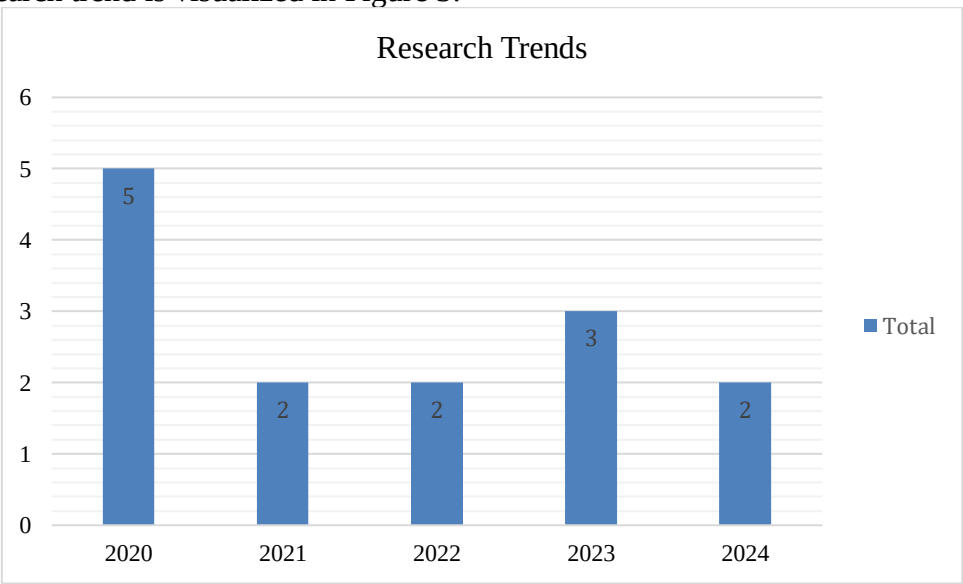

Figure 3. Research Trends Graph

The results of the general literature search on the Scopus database use PoP software with keywords ("problem-based learning" AND "critical thinking") that have been stored in the RIS extension and entered into the "Mendeley" software as the library management software. Articles included in Mendeley are selected based

on the inclusion and exclusion criteria in table 1. The number of articles that are the primary reference in this study is 20 that have met the inclusion criteria visualized in figure 4.

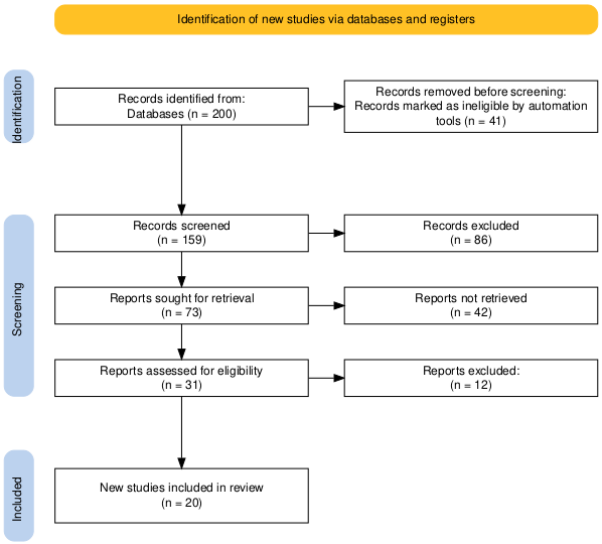

Figure 4. PRISMA Flow Diagram

Articles and literature that meet the inclusion criteria of this study are analyzed based on the problem, objectives, models/hypotheses, theories, methods, populations, and research results. The results of the analysis are included in Table 3. There are five types of research subjects used in the analyzed articles, namely Elementary School (SD), Secondary School, Junior High School (SMP), Senior High School (SMA), and Higher Education. The number of research whose subjects were elementary school students amounted to 1 article, high school amounted to 4 articles, junior high school amounted to 1 article, high school amounted to 3 articles, and tertiary education amounted to 11 articles.

Table 2. Types of Research Subjects

Subject	Number
SD	1
Secondary school	4
SMP	1
SMA	3
College	11
Sum	20

Based on the results of literature searches, it is known that problem-based learning models are widely used at the college. Through PBL, students are placed in real situations that require in-depth analysis. They must identify problems, gather information, and evaluate various solutions. This process encourages students to think critically about multiple aspects of the problem faced (Shorey et al., 2021)

Literature Review Results

Table 3. Literature Review Results

Reference	Problem	Purpose	Method and Population	Result
(Seruni et al., 2020)	Lack of critical thinking skills among college students.	Analysis of the effectiveness of the use of e-modules developed using the Flip PDF Professional application to improve students' critical thinking skills through the Problem-Based Learning (PBL) model	The analysis used the non-parametric Wilcoxon match pair test, with critical thinking skills test instruments through pre-test and post-test. The population of this research is Sixth-semester (6) students in the Chemistry Education Study Program, FMIPA, UNJ.	Critical thinking skills have significantly improved through the use of e-modules.
(Zamroni et al., 2020)	Lack of critical thinking skills among prospective counsellor students.	Analysis of the effectiveness of using blended learning with the PBL model to improve critical thinking skills of prospective counsellor students.	Experimental method with actual experiment research design. The population of this research is guidance and counselling students at Muria Kudus University who are taking a counsellor's personal development course.	There is an improvement in students' critical thinking skills through blended learning and PBL.

Reference	Problem	Purpose	Method and Population	Result
(Ahdhianto et al., 2020)	There are unsatisfactory results in mathematics subjects caused by a lack of critical thinking skills.	Improve critical thinking and problem-solving skills in mathematics subjects using problem-based learning (PBL).	• 1-way MANOVA test. • 1-way ANOVA test. • The population of this research is fifth-grade students at SD Gunungkidul, Nganjuk.	Students participating in PBL have improved their problem-solving skills. Students participating in PBL have improved their critical thinking skills.
(Silviariza et al., 2021)	The demands of the 21st century for students to improve their critical thinking skills regarding the orientation process and analyze problems from a spatial perspective	Improve critical thinking skills by using the PBL Spatial learning model (a combination of the PBL model and Spatial approach.	Test T. The population of this research is the Student of Geography Study Program, Faculty of Social Sciences, State University of Malang.	There is an increase in critical thinking skills in geography study program students who use the SPBL learning model.
(Waite et al., 2020)	Limited data supports improved learning outcomes, critical thinking skills, and	Demonstrate scientific evidence regarding improved learning outcomes, critical thinking	Retrospective cohort studies. The population of this research is students of the Pharmacy Profession Program,	There was a significant difference in academic performance between students who studied in class using PBL and

Reference	Problem	Purpose	Method and Population	Result
	problem-solving using PBL in places of study (universities) that do not use PBL from the start.	skills, and problem-solving in students who study in the classroom using PBL.	Philadelphia College of Pharmacy, University of the Sciences.	students who did not follow it.
(Mardi et al., 2021)	Lack of professionalism of accountants in Indonesia due to lack of interpersonal skills and critical thinking among accountants.	To know the difference in the level of critical thinking skills of accounting students who apply PBL and Guided Discovery Learning (GDL).	Quantitative methods with experimental approaches. The population of this research is students of the Accounting Study Program.	There is a difference in the level of critical thinking skills of accounting students who apply PBL and Guided Discovery Learning, but students in a class with the GDL model have higher scores than those in a class with the PBL model.
(Zhao et al., 2024)	Lack of attention to education regarding burn treatment in the surgical specialist program makes learning practices in the classroom monotonous.	Increase satisfaction with learning using the PBL learning model combined with short videos about learning.	Quantitative methods. The population of this research is medical students interning at the First Affiliated Hospital of Wannan Medical Faculty.	There was an increase in critical thinking skills in students who learned using the PBL model combined with short videos, so student satisfaction with learning increased.

Reference	Problem	Purpose	Method and Population	Result
(Gumisiriza h et al., 2024)	Fulfilment of Uganda's 2040 vision to implement the Sustainabl e Developm ent Goals (SDGs) by applying the PBL model in learning to improve students' critical thinking skills and problem-solving skills.	Evaluate the impact of using the Problem-Based Learning (PBL) model combined with videos taken from YouTube on students' understandin g of simple machine concepts.	Non-equivalent analysis of pre-test and post-test test results. The population of this research is students who are in a second-level secondary school in Sheema District, Uganda.	There is an increase in students' understanding through their critical thinking skills obtained through learning with the PBL learning model combined with videos taken from YouTube.
(Solissa et al., 2024)	There is a need to improve critical thinking skills and problem-solving abilities.	Knowing the improvement of student learning achievement by using the PBL and Problem Solving (PS) learning models	Quasi-experimental method with a non-equivalent comparative model of pre-test and post-test results. The population of this research is students of the Physical Education, Health, and Recreation Study Program, Faculty of Teacher Training and	The learning achievement of students who participated in learning with the PBL model was higher than that of the PS model.

Reference	Problem	Purpose	Method and Population	Result
			Education, Pattimura University.	
(Amin et al., 2020)	Lack of critical thinking skills and caring attitude towards the environment among students.	Knowing the influence of the PBL learning model on critical thinking skills and caring attitudes towards the environment.	Quasi experiment. The population of this research is students of the Social Science Education Study Program, Maulana Malik Ibrahim State Islamic University Malang, academic year 2018/2019.	• There are differences in students' critical thinking skills before and after implementing the PBL model. • There are differences in caring attitudes towards the student environment before and after implementing the PBL model.
(Y Hairun et al., 2020)	The demands of the 21st century and the Industrial Revolution 4.0 to integrate critical thinking skills into mathematics learning.	Analyze the needs of learning resources and design worksheets for students with the PBL learning model.	Research and Development with the ADDIE model. The population of this research is grade 8 students of Muhammadiyah Junior High School (SMP) Bantul, Yogyakarta, academic year 2019/2020.	The use of PBL-based worksheets can improve critical thinking skills.
(Taningrum et al., 2024)	Students who have difficulty	Knowing the learning outcomes and	Experiment with pre-test and post-test	There were significant differences in

Reference	Problem	Purpose	Method and Population	Result
	understanding the material regarding tactics and strategies in football.	critical thinking skills of students who have participated in problem-based learning with animated videos on football game materials.	group designs. The population of this research is students of grade twelve SMA Negeri 1 Seyegan.	students' learning outcomes and critical thinking skills before and after participating in learning with the PBL model using animated videos.
(Susanto et al., 2022)	The demand for teachers to have exciting learning media aligns with technological developments.	To know the Development of thinking skills of students who use E-Books with a problem-based learning model.	Research and development (rnd) with the ADDIE model. The population of this research is fifth-grade elementary school students located in Jagakarsa District, South Jakarta.	Significant differences exist in students' critical thinking skills before and after PBL-based E-Books.
(Arifin et al., 2020)	Competition in improving human resources in the industrial era 4.0, especially in preparing students to compete in the world of work.	Compare the effectiveness of the problem-based learning model (PBL) with the direct instruction (DI) learning model.	Quasi-experimental with the MANCOVA test. The population of this research is students at SMAN 1 Wringinanom Gresik, SMAN 1 Driyorejo Gresik, and SMAN 1 Kedamean Gresik.	The critical thinking skills of students who learn with the PBL model are better than the DI model.

Reference	Problem	Purpose	Method and Population	Result
(Nicholus et al., 2024)	There is a need to improve the critical thinking skills and academic performance of secondary school-level learners in Uganda.	Evaluation of the impact of using the problem-based learning model (PBL) using video on critical thinking skills and academic performance of secondary school students in Uganda.	Quasi-experimental. The population of this research is students in four schools in the Sheema district, totalling 144 students.	Using a problem-based learning model using video can improve the critical thinking skills and academic performance of secondary school level learners in Uganda.
(S.-Y. Yang & OH, 2023)	Problem-based learning models traditionally using texts cannot describe patients' clinical situations and symptoms to nursing students.	Comparing the effectiveness of using the learning model using video with traditional text.	Quasi-experimental with chi-square test, Fisher's exact test, and independent t-test and variance analysis. The population of this research is third-level nursing students (3) Nursing Colleges in South Korea.	• The experimental group reported a higher mean post-test score for learning motivation. • The experimental group reported a higher average post-test score for academic self-efficacy. • The experimental group reported a higher average post-test score for self-learning.
(Salazar et al., 2023)	Difficulties in	Improving students'	Mix methods with	The problem-based learning

Reference	Problem	Purpose	Method and Population	Result
	learning physics during the COVID-19 pandemic.	critical thinking skills in physics learning using a problem-based learning model with virtual (online) classes.	quantitative, qualitative, and deductive inductive approaches. The population of this research is first-semester students of the Study Program Engineering, Instituto Politécnico Nacional (IPN), located in Ciudad de México, Mexico.	model with virtual classes can improve students' critical thinking skills and academic performance.
(Pitorini et al., 2024)	There is a need to improve critical thinking skills to face the challenges of the 21st century.	To test the effectiveness of using e-modules based on the PBL learning model combined with Socratic Dialogue on environmental change in improving students' critical thinking skills.	Quasi-experimental. The population of this research is grade X students of SMAN 1 Karanganyar.	There is an increase in students' critical thinking skills using e-modules based on the PBL learning model combined with Socratic Dialogue.
(Marthaliakirana et al., 2022)	The 21st-century challenge of answering socioscientific issues	To determine the effect of applying the PBL learning model with metacognitive prompts on	Quasi-experimental The population of this research is grade 11 students who	There was a significant difference in argumentation and critical thinking skills between

Reference	Problem	Purpose	Method and Population	Result
	(SSI) through critical thinking skills.	students' argumentation and critical thinking skills in biology subjects.	took the biology specialization, totalling 121 students.	students who participated in problem-based learning with metacognitive instructions (M-PBL) compared to students who participated in high-intensity (H-PBL) and low-intensity problem-based learning (L-PBL).
(Budakoğlu et al., 2023)	Challenges of applying problem-based learning to online learning.	Determine the effectiveness of using animation in online problem-based learning (e-PBL).	Design-based research with three phases, namely design, analysis, and redesign. The population of this research is University of Gazi Faculty of Medicine students located in Ankara, Turkey.	• A positive relationship exists between students' attitudes towards e-PBL and their academic grade point average (GPA). • There is a positive relationship between Clinical Objective Reasoning Exams (CORE) scores and students' academic average (GPA). • The multimedia animation-supported e-PBL environment positively impacts students'

Reference	Problem	Purpose	Method and Population	Result
				knowledge, skills, and attitudes.

The findings of this study confirm several well-established trends in problem-based learning (PBL) with multimedia use while also revealing interesting gaps for further exploration. The results align with previous studies highlighting the role of multimedia in enhancing students' critical thinking skills and learning satisfaction. For instance, Zhao et al. (2024) found that using short videos in PBL significantly increased medical students' learning satisfaction, positively impacting their critical thinking skills. Similar findings were reported by Budakoğlu et al. (2023), who noted that animations in an e-PBL environment improved students' knowledge and critical thinking abilities. Furthermore, studies like Nicholus et al. (2024), conducted on secondary school students, also demonstrated the positive effects of video use in PBL on academic performance and critical thinking skills. However, some contradictions emerge, such as Budakoğlu et al. (2023) observation that the effectiveness of multimedia-supported PBL is comparable to traditional PBL without multimedia, with student motivation playing a crucial role in determining success. Another key insight is the limited adoption of multimedia in PBL, as evidenced by only 6 out of 20 reviewed articles explicitly addressing its integration despite its proven potential.

This study also has several limitations worth noting. First, it predominantly focuses on specific populations, such as medical students or secondary school students in certain geographic regions like South Korea, Uganda, and Turkey. This narrow focus restricts the diversity of insights and raises questions about the applicability of findings to other contexts with different student characteristics. Second, most studies assess the short-term impacts of multimedia use in PBL, leaving the long-term effects largely unexplored. Third, the predominance of quasi-experimental designs limits researchers' ability to draw strong causal conclusions. Methodologies like research and development, which could offer deeper insights into implementation aspects, were only employed in two studies (Budakoğlu et al., 2023; Y Hairun et al., 2020). Additionally, disparities in digital infrastructure and students' familiarity with multimedia tools are not consistently evaluated, potentially affecting learning outcomes.

Regarding generalizability, the positive impact of multimedia on students' critical thinking skills is likely applicable across various educational levels and disciplines. This trend was observed in diverse contexts, including primary, secondary, and higher education. However, challenges in generalizing these findings arise due to factors influencing implementation, such as the type of multimedia used, teachers' expertise in integrating technology, and students' motivation. Cultural and institutional factors also warrant consideration, as differences in values, educational policies, and access to technology can significantly impact learning outcomes.

The implications of this study are extensive and relevant to various stakeholders. For future researchers, these findings encourage further exploration of the long-term effects of multimedia-supported PBL and comparative studies on the

effectiveness of different types of multimedia, such as videos, animations, e-books, or interactive tools. Expanding study populations to include diverse educational levels, cultural backgrounds, and institutional settings can also provide broader insights into multimedia applications in PBL. For educators and practitioners, the study highlights the importance of teacher training in effectively integrating multimedia into PBL. Training should address technical aspects and strategies to motivate students and enhance their engagement. This research underscores the need for policymakers and administrators to support multimedia tools and provide the necessary technological infrastructure to facilitate digital learning environments. Policies promoting the ethical and effective use of digital media in classrooms should also be developed to ensure optimal learning outcomes.

CONCLUSION

PBL models have been proven to positively impact students' critical thinking skills because PBL encourages students to actively explore solutions to given problems, engage more deeply with learning materials, and develop problem-solving strategies based on scientific references. Previous studies have shown that students participating in PBL experience significant improvements in critical thinking skills across various contexts and educational levels. Furthermore, multimedia integration into PBL enhances critical thinking skills by providing engaging and interactive learning experiences. Tools such as videos, animations, and e-books help students understand complex concepts, stimulate cognitive processes, and motivate active participation in problem-solving activities. However, the effectiveness of multimedia-supported PBL is heavily influenced by factors such as student motivation and teachers' ability to integrate technology effectively.

Research on PBL, multimedia, and critical thinking skills shows a consistent trend, with multimedia positively impacting learning outcomes. However, the adoption of multimedia in PBL remains limited, with only 6 out of 20 reviewed articles explicitly addressing its integration. Most studies employ quantitative methods with quasi-experimental designs to assess short-term impacts, while research on long-term effects is still rare. The research subjects discussing these three variables include medical students, secondary school students, high school students, and elementary school students, spanning countries such as South Korea, Turkey, Uganda, and Indonesia.

The most commonly used research methods are quantitative approaches, particularly quasi-experimental designs, which typically involve pre-test and post-test evaluations to measure changes in critical thinking skills. Additionally, some studies, such as those by Y Hairun et al. (2020) and Budakoğlu et al. (2023), use research and development methods to explore the design and implementation of multimedia-based PBL environments. Thus, while numerous studies have demonstrated the significant benefits of PBL and multimedia, further exploration is needed regarding long-term impacts, increased adoption of multimedia, and implementation in diverse educational and cultural contexts.

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