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The Effect of Digital Media-Assisted Problem Based Learning on Junior High School Students' Critical Thinking Skills in Mathematics Learning

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ABSTRACT

Mathematical critical thinking skills are essential competencies in twenty-first century education; however, many junior high school students still demonstrate low abilities in analyzing, evaluating, and solving mathematical problems. This study aimed to analyze the effect of Digital Media-Assisted Problem Based Learning (PBL) on students' mathematical critical thinking skills. The research employed a quantitative approach using a quasi-experimental design with a pretest-posttest control group design. The participants consisted of junior high school students divided into an experimental class and a control class. Data were collected through mathematical critical thinking tests, observations, and documentation. The data were analyzed using descriptive statistics, normality and homogeneity tests, independent sample t-tests, and N-Gain analysis. The findings revealed that the experimental class taught using Digital Media-Assisted PBL achieved a higher posttest mean score (84.37) compared to the control class (72.15). Furthermore, the experimental class obtained an N-Gain score of 0.64, while the control class achieved 0.38. These results indicate that the integration of digital media within the PBL model effectively improved students' mathematical critical thinking skills by promoting interactive, contextual, and student-centered learning experiences. Therefore, Digital Media-Assisted PBL can be considered an effective instructional strategy for enhancing students' higher-order thinking skills in mathematics learning.

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1. INTRODUCTION

Critical thinking skills have become one of the essential competencies required in twenty-first century education, particularly in mathematics learning. Mathematics is not only oriented toward obtaining correct answers, but also toward developing students' abilities to analyze problems, evaluate information, formulate arguments, and draw logical conclusions. In the context

of modern education, students are expected to possess higher-order thinking skills that enable them to solve contextual and complex problems effectively. However, the reality in many junior high schools indicates that students' mathematical critical thinking skills remain relatively low. This condition has become a serious concern because critical thinking is closely related to students' academic achievement, problem-solving abilities, and readiness to face the challenges of the digital era. Several recent studies revealed that students still experience difficulties in fulfilling indicators of critical thinking, including interpretation, analysis, evaluation, and inference in mathematical problem solving. Difficulties were identified in various mathematical topics such as systems of linear equations in two variables (SPLDV), geometry, fractions, and algebraic concepts (Susandi, 2021; Rahmawati & Rizaldi, 2025; Kanwal et al., 2024; Fitriani & Kowiyah, 2022; Harahap et al., 2024). These findings indicate that many students are still unable to connect mathematical concepts with contextual situations and often rely solely on procedural calculations without understanding the reasoning process underlying the solutions.

The low level of students' mathematical critical thinking skills is inseparable from the learning approaches commonly implemented in classrooms. Mathematics instruction in many schools still tends to be teacher-centered, where teachers dominate classroom activities through lectures, demonstrations, and direct explanations of formulas and procedures. In this learning environment, students become passive recipients of information rather than active constructors of knowledge. As a result, opportunities for students to develop reasoning, inquiry, and reflective thinking skills are limited. Susandi (2021) emphasized that conventional mathematics learning often prioritizes memorization and procedural completion of tasks rather than encouraging students to explore alternative solutions and engage in analytical reasoning. Similarly, Pradana and Noer (2023) argued that the lack of meaningful student engagement in mathematical investigations contributes significantly to the weak development of critical thinking skills. Kanwal et al. (2024) further explained that mathematics learning that neglects the management of students' thinking processes may hinder students from developing analytical and evaluative competencies needed in problem-solving situations. Consequently, students frequently encounter difficulties when facing non-routine mathematical problems that require logical reasoning and critical analysis.

In response to these educational challenges, educators and researchers have increasingly emphasized the importance of implementing innovative learning models capable of promoting students' higher-order thinking skills. One of the learning approaches that has received considerable attention is Problem Based Learning (PBL). PBL is a student-centered instructional model that emphasizes learning through authentic and contextual problem-solving activities. In PBL classrooms, students are encouraged to identify problems, analyze information, collaborate with peers, propose solutions, and reflect on their learning processes. This learning model positions students as active participants who construct knowledge through inquiry and investigation rather than passive recipients of information. Several studies have demonstrated that PBL is effective in improving students' mathematical critical thinking skills. A meta-analysis conducted by Yohannes et al. (2021) involving fifteen research articles revealed that PBL had a high effect size of 0.97 on junior high school students' mathematical critical thinking abilities. The study also found that the effectiveness of PBL was relatively stable across grade levels, publication years, and sample sizes, although the duration of treatment significantly influenced learning outcomes. These findings suggest that sustained implementation of PBL can substantially enhance students' critical thinking competencies in mathematics learning.

The effectiveness of PBL in fostering critical thinking has also been confirmed by various experimental and qualitative studies. Dewi et al. (2025) found that students taught using PBL demonstrated better analytical thinking and problem-solving skills compared to those taught through conventional instruction. Amanda and Wahyuningsih (2024) similarly reported that PBL encouraged students to become more collaborative and reflective during mathematical discussions. Abdullah et al. (2025) further highlighted that PBL facilitated deeper conceptual understanding because students actively explored and evaluated different problem-solving strategies. These findings indicate that PBL provides opportunities for students to engage in meaningful learning experiences that stimulate critical inquiry, reasoning, and decision-making processes. Nevertheless, despite the positive impact of PBL, the implementation of this learning model in mathematics

classrooms still faces several limitations. Some students experience difficulties in maintaining motivation and engagement during problem-solving activities, especially when learning resources and media are insufficiently interactive or contextual. Therefore, integrating digital media into PBL has emerged as a promising strategy to enhance the effectiveness of mathematics instruction.

The rapid development of digital technology in education has created opportunities for teachers to integrate various digital media into learning processes. Digital media can facilitate interactive, flexible, and visually engaging learning experiences that support students' understanding and critical thinking development. In the context of PBL, digital media can function as learning resources, communication tools, simulation platforms, and interactive environments that enrich students' problem-solving experiences. Recent studies have explored various forms of digital media-assisted PBL and their impacts on students' critical thinking skills. Interactive digital comics, for example, were found to significantly improve students' abilities to analyze, conclude, and connect ideas in mathematics and economics learning contexts (Bintan & Rahman, 2025; Darmayanti et al., 2022). These findings indicate that visual and narrative-based digital media can stimulate students' cognitive engagement and conceptual understanding during problem-solving activities.

In addition, the use of Google Sites in PBL-based statistics learning for junior high school students demonstrated higher gains in critical thinking skills compared to conventional learning approaches. Dewi et al. (2025) reported that students in the experimental group achieved an N-gain score of 0.20, whereas the control group obtained only 0.10. Similarly, interactive e-worksheets integrated with digital platforms such as Edpuzzle and digital worksheets showed moderate N-gain improvements and significantly increased students' critical thinking scores in mathematics learning (Firmansyah & Andriyani, 2023; Utaminingsih et al., 2024). Interactive video-assisted PBL in chemistry learning also produced positive results, with an N-gain score of 0.63 categorized as moderate and higher post-test scores than conventional classrooms (Romadhoni et al., 2025). Moreover, interactive media developed using Canva demonstrated significant differences between pre-test and post-test critical thinking scores among elementary school students (Amiliya & Ismiyanti, 2025). The integration of artificial intelligence (AI)-based interactive media within PBL was also reported to explain approximately fifty percent of the variance in students' critical thinking skills in science learning (Fatih, 2025). Furthermore, systematic literature reviews conducted by Jihanifa et al. (2025) and Kartika et al. (2025) concluded that multimedia and animation-assisted PBL were generally effective in enhancing students' critical thinking abilities across various subjects. Collectively, these studies indicate that integrating digital media into PBL contributes positively to students' critical thinking development by increasing engagement, visualization, interactivity, and accessibility in learning.

Although previous studies have confirmed the positive impact of digital media-assisted PBL, several research gaps remain unresolved. First, many existing studies primarily focus on research and development (R&D) of digital learning media and limited-scale experimental trials. Consequently, evidence regarding the long-term effectiveness and sustainability of digital media-assisted PBL implementation remains limited (Dewi et al., 2025; Yohannes et al., 2021). Second, comparative studies examining the effectiveness of different types of digital media integrated within PBL across various mathematics topics and educational levels are still relatively scarce. Most studies concentrate on general mathematics learning without specifically analyzing particular mathematical topics that may present distinct cognitive challenges for students (Darmayanti et al., 2022; Rahmawati & Rizaldi, 2025). Third, only a limited number of studies investigate how students with different initial abilities respond to digital media-assisted PBL interventions. This issue is important because variations in prior knowledge and cognitive readiness may influence students' participation and critical thinking development during problem-solving activities (Fitriani & Kowiyah, 2022; Harahap et al., 2024). In addition, systematic literature reviews have recommended the need for more comprehensive mixed-method studies, adaptive AI-based learning platforms, and large-scale implementations aligned with the Merdeka Curriculum framework (Jihanifa et al., 2025; Kartika et al., 2025; Fatih, 2025). These recommendations indicate that further research is necessary to provide deeper empirical evidence regarding the effectiveness and practical implementation of digital media-assisted PBL in mathematics education.

Based on these considerations, this study offers novelty by specifically investigating the effect of digital media-assisted Problem Based Learning on junior high school students' critical thinking skills in mathematics learning through a contextual and technology-integrated instructional approach. Unlike previous studies that generally focused on limited media development or broad learning contexts, this study emphasizes the integration of interactive digital media within PBL to stimulate students' analytical, evaluative, and inferential thinking processes in mathematics learning. This research also contributes to the growing discourse on technology-enhanced mathematics instruction by examining how digital media can optimize the implementation of PBL in fostering students' higher-order thinking skills. Furthermore, this study attempts to provide empirical evidence relevant to the implementation of innovative learning practices aligned with twenty-first century educational demands and the Merdeka Curriculum orientation toward student-centered and technology-supported learning.

Therefore, the purpose of this study is to analyze the effect of digital media-assisted Problem Based Learning on junior high school students' critical thinking skills in mathematics learning.

2. LITERATURE REVIEW

Mathematical Critical Thinking Skills

Critical thinking skills in mathematics refer to students' abilities to analyze mathematical problems logically, evaluate information systematically, interpret data accurately, and formulate rational conclusions based on evidence. In mathematics learning, critical thinking is closely associated with higher-order thinking skills because students are required not only to memorize formulas but also to understand concepts and apply them in solving contextual problems. Students with strong mathematical critical thinking skills are generally capable of identifying relationships among concepts, constructing logical arguments, and evaluating alternative problem-solving strategies effectively. Critical thinking also supports students in developing independent learning habits and reflective reasoning processes that are essential in twenty-first century education. However, many students still experience difficulties in demonstrating indicators of critical thinking such as interpretation, analysis, evaluation, and inference during mathematics learning activities (Susandi, 2021; Fitriani & Kowiyah, 2022).

The low level of mathematical critical thinking skills among junior high school students has become a significant educational concern in various countries, including Indonesia. Several studies reported that students often fail to solve non-routine mathematical problems because they rely heavily on procedural approaches and memorization rather than conceptual understanding and analytical reasoning. This condition is influenced by conventional teacher-centered instructional practices that limit students' opportunities to engage in inquiry, discussion, and reflective thinking. As a result, students tend to become passive learners who depend on teacher explanations rather than actively constructing mathematical knowledge independently. In addition, limited exposure to contextual problem-solving activities contributes to students' weak analytical and evaluative abilities in mathematics learning (Rahmawati & Rizaldi, 2025; Kanwal et al., 2024).

Problem Based Learning (PBL)

Problem Based Learning (PBL) is a student-centered instructional model that emphasizes learning through authentic and contextual problem-solving experiences. In PBL, students are encouraged to identify problems, gather relevant information, discuss possible solutions collaboratively, and reflect on their learning processes. This learning model promotes active participation, inquiry, communication, and critical reasoning, making it highly relevant for developing higher-order thinking skills in mathematics learning. PBL also creates opportunities for students to connect mathematical concepts with real-life situations, thereby improving conceptual understanding and problem-solving abilities. Through collaborative investigations and discussions, students learn to evaluate arguments, justify solutions, and make decisions based on logical reasoning processes (Yohannes et al., 2021; Abdullah et al., 2025).

The implementation of PBL in mathematics education has shown positive impacts on students' critical thinking skills and academic achievement. Previous studies revealed that students taught using PBL tend to demonstrate better analytical thinking, problem-solving abilities, and collaborative learning skills compared to students taught through conventional methods. A meta-analysis conducted by Yohannes et al. (2021) indicated that PBL had a high effect size in improving junior high school students' mathematical critical thinking skills. Similarly, experimental studies found that PBL encourages students to become more active in exploring mathematical concepts, discussing alternative solutions, and evaluating problem-solving strategies critically. The effectiveness of PBL is strongly influenced by the quality of learning design, contextual problems, and the duration of instructional implementation (Amanda & Wahyuningsih, 2024; Dewi et al., 2025).

Digital Media in Mathematics Learning

Digital media have become increasingly important in modern mathematics education because they provide interactive, visual, and flexible learning environments that can enhance students' engagement and understanding. Digital media include various technological tools such as interactive videos, digital worksheets, educational websites, animations, learning applications, and AI-based learning platforms. In mathematics learning, digital media can help students visualize abstract concepts, access learning materials more easily, and participate actively in interactive problem-solving activities. The integration of digital technology also supports student-centered learning approaches that encourage exploration, collaboration, and independent learning. As educational environments continue to adapt to technological advancements, digital media are considered effective tools for facilitating higher-order thinking skills development (Firmansyah & Andriyani, 2023; Utaminingsih et al., 2024).

Several studies have demonstrated that digital media positively influence students' critical thinking skills in various learning contexts. Interactive digital media such as videos, animations, and digital comics can stimulate students' curiosity, increase learning motivation, and improve conceptual understanding. Moreover, digital learning platforms enable students to access contextual learning resources and engage in collaborative discussions that support analytical thinking processes. Research findings showed that students who learned through digital interactive media achieved higher critical thinking scores compared to those who learned through conventional instruction. The effectiveness of digital media is also influenced by the interactivity, accessibility, and relevance of the learning content to students' real-life experiences (Bintan & Rahman, 2025; Amiliya & Ismiyanti, 2025).

Digital Media-Assisted Problem Based Learning

The integration of digital media into Problem Based Learning has emerged as an innovative instructional approach capable of enhancing students' critical thinking skills in mathematics learning. Digital media-assisted PBL combines contextual problem-solving activities with interactive technological tools that support students' engagement, collaboration, and analytical reasoning. Through digital platforms, students can access multimedia resources, participate in online discussions, complete interactive assignments, and explore mathematical concepts more independently. This integration creates more dynamic and meaningful learning experiences because students are actively involved in investigating and solving problems using technology-supported resources. Furthermore, digital media can facilitate visualization and simulation processes that help students understand complex mathematical concepts more effectively (Dewi et al., 2025; Darmayanti et al., 2022).

Recent studies revealed that digital media-assisted PBL significantly improves students' mathematical critical thinking skills compared to traditional learning approaches. The use of interactive digital comics, Google Sites, e-worksheets, interactive videos, and AI-assisted learning platforms within PBL environments has been shown to increase students' analytical abilities, problem-solving skills, and conceptual understanding. In addition, digital media-assisted PBL contributes to higher student motivation and participation because learning activities become more engaging and contextual. Students are encouraged to collaborate, evaluate information critically,

and formulate solutions through technology-enhanced inquiry processes. Consequently, digital media-assisted PBL is considered an effective strategy for supporting the development of twenty-first century competencies in mathematics education (Jihanifa et al., 2025; Kartika et al., 2025).

Previous Studies and Research Gap

Numerous studies have examined the effectiveness of PBL and digital media integration in improving students' critical thinking skills. Previous research generally confirmed that PBL positively affects students' higher-order thinking abilities, while digital media increase interactivity and learning engagement. However, many existing studies still focus primarily on media development research and limited-scale implementation. Most studies investigate general mathematics learning contexts without specifically analyzing the effectiveness of digital media-assisted PBL in certain mathematical topics or among students with different initial ability levels. Consequently, empirical evidence regarding the broader and long-term impact of this instructional approach remains limited (Rahmawati & Rizaldi, 2025; Harahap et al., 2024).

In addition, systematic literature reviews recommended further investigations involving adaptive digital platforms, AI-assisted learning systems, and large-scale implementations aligned with modern educational curricula. Previous studies also rarely explored how digital media-assisted PBL influences students' critical thinking indicators comprehensively, including interpretation, analysis, evaluation, and inference. Therefore, further research is necessary to provide deeper insights into the effectiveness of digital media-assisted Problem Based Learning in improving junior high school students' critical thinking skills in mathematics learning. This study attempts to address these gaps by focusing specifically on the integration of digital media within PBL to enhance mathematical critical thinking competencies among junior high school students (Fatih, 2025; Jihanifa et al., 2025).

3. METHOD

This study employed a quantitative approach using a quasi-experimental research design to examine the effect of Digital Media-Assisted Problem Based Learning (PBL) on junior high school students' mathematical critical thinking skills. The research was conducted in a junior high school involving two classes selected through purposive sampling techniques, consisting of an experimental class and a control class. The experimental class received mathematics instruction through Digital Media-Assisted PBL, while the control class was taught using conventional learning methods. The study applied a pretest-posttest control group design to identify differences in students' critical thinking skills before and after the treatment. The subjects of the study were seventh- or eighth-grade students who studied mathematics topics relevant to contextual problem-solving activities. The digital media utilized in the learning process included interactive learning videos, digital worksheets, and online learning platforms integrated into the PBL stages, such as problem orientation, investigation, discussion, presentation, and reflection. Data collection techniques consisted of mathematical critical thinking tests, classroom observations, and documentation. The critical thinking test was designed based on indicators including interpretation, analysis, evaluation, and inference, while observation sheets were used to identify students' participation and learning activities during the implementation of Digital Media-Assisted PBL. Documentation techniques were also used to collect supporting data related to the learning process and students' learning outcomes.

The collected data were analyzed using both descriptive and inferential statistical techniques. Descriptive statistics were employed to describe students' pretest and posttest scores, including the mean, standard deviation, maximum score, and minimum score in both classes. Before conducting hypothesis testing, prerequisite analyses consisting of normality and homogeneity tests were performed to ensure that the data met the assumptions required for parametric statistical analysis. The effectiveness of Digital Media-Assisted PBL in improving students' mathematical critical thinking skills was analyzed using an independent sample t-test to compare the posttest results between the experimental and control groups. In addition, the normalized gain (N-gain) test was calculated to determine the level of improvement in students'

critical thinking skills after the treatment. Observation and documentation data were analyzed qualitatively to support the interpretation of quantitative findings regarding students' engagement, interaction, and participation during mathematics learning activities. The results of these analyses were used to determine whether Digital Media-Assisted Problem Based Learning significantly influenced junior high school students' critical thinking skills in mathematics learning.

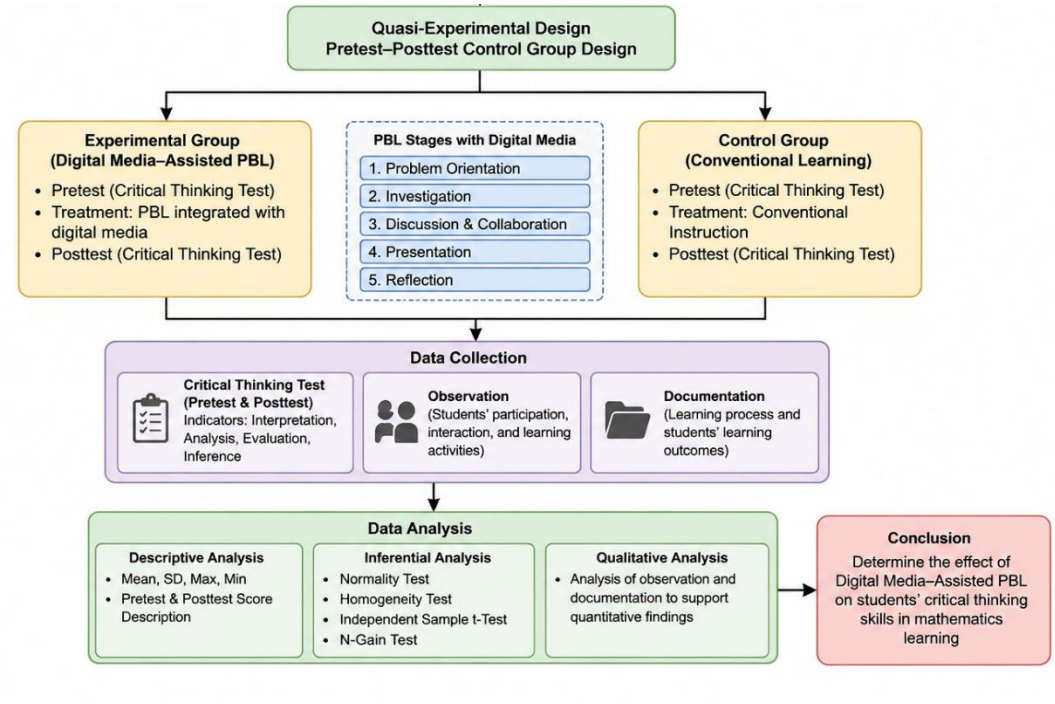

Figure 1. Diagram Conceptual Research

4. RESULTS AND DISCUSSION

Before conducting hypothesis testing, descriptive statistical analysis was carried out to identify the differences in students' mathematical critical thinking skills between the experimental class taught using Digital Media-Assisted Problem Based Learning (PBL) and the control class taught using conventional learning methods. The analysis included the mean scores of pretest and posttest results as well as the N-Gain scores to determine the level of improvement in students' critical thinking skills after the implementation of the learning treatment.

Table 1. Descriptive Statistics of Students' Mathematical Critical Thinking Skills

Group	Pretest Mean	Posttest Mean	N-Gain	Category
Experimental Class (Digital Media-Assisted PBL)	56.24	84.37	0.64	Moderate
Control Class (Conventional Learning)	54.89	72.15	0.38	Moderate
Difference	1.35	12.22	0.26	—

Based on Table 1, the results indicate that both the experimental and control classes experienced improvements in mathematical critical thinking skills after the learning process. However, the improvement in the experimental class was significantly higher than that of the control class. The experimental class obtained a posttest mean score of 84.37, while the control class achieved 72.15. In terms of learning improvement, the experimental class reached an N-Gain score of 0.64, categorized as moderate and close to the high category, whereas the control class only achieved an N-Gain score of 0.38. These findings suggest that the implementation of Digital Media-Assisted Problem Based Learning was more effective in enhancing students' mathematical

critical thinking skills compared to conventional learning methods. The integration of digital media within the PBL model provided more interactive, contextual, and engaging learning experiences, enabling students to develop better analytical, evaluative, and problem-solving abilities during mathematics learning activities.

Discussion

The findings of this study indicate that the implementation of Digital Media-Assisted Problem Based Learning (PBL) had a positive effect on junior high school students' mathematical critical thinking skills. This can be observed from the significant increase in the posttest scores and N-Gain results achieved by the experimental class compared to the control class. The experimental class that received Digital Media-Assisted PBL obtained a posttest mean score of 84.37 with an N-Gain score of 0.64, while the control class taught through conventional learning achieved a posttest mean score of 72.15 with an N-Gain score of 0.38. These findings demonstrate that the integration of digital media into PBL created a more effective learning environment for developing students' mathematical critical thinking abilities. The results of this study are consistent with the primary objective of the research, namely to analyze the effect of Digital Media-Assisted Problem Based Learning on students' critical thinking skills in mathematics learning.

The improvement in students' critical thinking skills in the experimental class confirms that Problem Based Learning is an effective instructional model for fostering higher-order thinking skills in mathematics education. Through PBL, students were actively involved in identifying problems, analyzing mathematical information, discussing alternative solutions, and reflecting on their reasoning processes. This learning process encouraged students to engage more deeply in analytical and evaluative thinking activities compared to traditional teacher-centered instruction. The findings align with the meta-analysis conducted by Yohannes et al. (2021), which reported that PBL had a high effect size of 0.97 on junior high school students' mathematical critical thinking skills. The meta-analysis further explained that PBL consistently produced positive effects across different grade levels, publication years, and sample sizes. In the present study, students in the experimental class demonstrated improved abilities in interpreting mathematical problems, evaluating information critically, and formulating logical conclusions. These improvements indicate that PBL successfully facilitated students' cognitive engagement and reflective reasoning during mathematics learning activities.

The positive influence of PBL on students' mathematical critical thinking skills can also be explained by the characteristics of the learning model itself. PBL emphasizes contextual and authentic problem-solving experiences that require students to construct knowledge actively rather than passively receiving information from teachers. During the implementation of Digital Media-Assisted PBL, students were encouraged to collaborate with peers, investigate mathematical problems independently, and present their solutions through discussion and reflection activities. These learning experiences stimulated students' analytical thinking processes because they had to evaluate information, justify their reasoning, and consider multiple perspectives before reaching conclusions. Abdullah et al. (2025) stated that PBL creates opportunities for students to engage in inquiry-based learning activities that directly train critical thinking indicators such as interpretation, analysis, evaluation, and inference. Similarly, Amanda and Wahyuningsih (2024) found that students who learned through PBL demonstrated significantly higher posttest critical thinking scores than students taught through conventional approaches. The present findings support these previous studies by confirming that PBL contributes positively to students' mathematical reasoning and problem-solving abilities.

In addition to the effectiveness of PBL, the integration of digital media played an important role in enhancing students' critical thinking skills during mathematics learning. Digital media provided interactive and visually engaging learning experiences that increased students' motivation, participation, and conceptual understanding. In this study, the use of digital media such as interactive videos, online learning platforms, and digital worksheets helped students visualize mathematical concepts more clearly and engage actively in problem-solving activities. The availability of multimedia resources enabled students to explore mathematical information independently, access contextual learning materials, and receive immediate feedback during learning activities. Consequently, students became more confident and motivated to participate in

discussions and analytical reasoning processes. These findings are in line with Firmansyah and Andriyani (2023), who reported that e-worksheet mathematics learning assisted by Edpuzzle significantly improved students' critical thinking skills with an approximate gain score of 84%. The researchers explained that interactive digital worksheets encouraged students to become more active in observing, analyzing, and evaluating mathematical problems.

The findings of this study also support previous research regarding the effectiveness of web-based digital media integrated within PBL environments. Dewi et al. (2025) found that the use of Google Sites within PBL-based statistics learning produced higher N-Gain scores than conventional learning approaches, indicating that digital media can optimize students' critical thinking development. Similarly, in the present study, students in the experimental class showed greater improvements in mathematical critical thinking skills because digital media provided more flexible and interactive learning opportunities. Through digital learning platforms, students could revisit learning materials, access contextual examples, and collaborate more effectively during group discussions. The interactivity offered by digital media enabled students to engage more deeply with mathematical problems and encouraged them to formulate more logical and systematic problem-solving strategies. This condition differs from conventional learning environments, where students often rely heavily on teacher explanations and textbook exercises without actively exploring mathematical concepts independently.

Furthermore, the integration of digital media into PBL contributed to improving students' engagement and collaborative learning processes. During the implementation of Digital Media-Assisted PBL, students demonstrated greater enthusiasm and participation in classroom activities because learning became more contextual and relevant to their daily experiences. Interactive digital media such as videos and digital worksheets helped students understand abstract mathematical concepts through visual representations and real-life problem contexts. As a result, students became more interested in discussing mathematical problems and proposing alternative solutions collaboratively. These findings are consistent with Pramasdyahsari et al. (2023), who found that STEM digital books integrated within project-based learning significantly improved students' mathematical critical thinking skills and four C competencies, including communication, collaboration, creativity, and critical thinking. The study also revealed that students became more active and motivated when learning activities incorporated digital media. The present study similarly demonstrates that digital media can create a more engaging and student-centered learning atmosphere that supports critical thinking development.

The effectiveness of Digital Media-Assisted PBL in improving mathematical critical thinking skills can also be explained through cognitive learning theory. According to constructivist perspectives, students learn more effectively when they actively construct knowledge through meaningful experiences and social interactions. PBL encourages students to solve authentic problems collaboratively, while digital media provide interactive resources that facilitate exploration and conceptual understanding. Through these learning experiences, students become more capable of connecting prior knowledge with new information and applying reasoning skills to solve mathematical problems. Utaminingsih et al. (2024) explained that digital interactive worksheets integrated with PBL effectively improved students' mathematical critical thinking skills because the learning activities explicitly incorporated critical thinking indicators into problem-solving tasks. Similarly, Firmansyah and Andriyani (2023) emphasized that digital media should be designed to encourage analytical reasoning, evaluation, and reflective thinking processes. In the present study, the digital media used within the PBL framework successfully supported these cognitive processes by providing contextual problems, visual representations, and interactive learning activities that stimulated students' reasoning abilities.

Another important finding of this study is that students in the experimental class demonstrated stronger collaborative and communicative abilities during mathematics learning activities. During group discussions, students actively exchanged ideas, evaluated peers' arguments, and justified their mathematical reasoning before reaching conclusions. This collaborative learning process contributed significantly to the development of critical thinking skills because students learned to consider multiple perspectives and defend their opinions using logical evidence. These findings are supported by Aliza et al. (2024), who reported that problem-

based interactive multimedia was valid, practical, and effective for improving students' critical thinking skills in junior high school mathematics learning. The researchers emphasized that multimedia-assisted learning environments encourage students to participate more actively in inquiry and discussion processes. In the present study, digital media facilitated students' communication and collaboration by enabling them to access shared learning resources and engage in interactive group activities during problem-solving sessions.

Although the findings of this study demonstrate the effectiveness of Digital Media-Assisted PBL, several challenges were identified during the implementation process. One of the main challenges involved students' varying levels of digital literacy and access to internet connectivity. Some students initially experienced difficulties in operating digital learning platforms and accessing online materials effectively. This issue occasionally affected the efficiency of learning activities, particularly during the early stages of implementation. These findings are consistent with Cahayati et al. (2025), who identified internet accessibility and students' digital literacy as significant challenges in implementing web-based digital learning environments. Similarly, Utaminingsih et al. (2024) noted that the successful implementation of digital media-assisted learning depends heavily on technological infrastructure and students' familiarity with digital tools. Therefore, teachers need to provide sufficient guidance and scaffolding to ensure that students can utilize digital media effectively during learning activities.

Another factor influencing the success of Digital Media-Assisted PBL is the teacher's readiness and instructional management skills. The implementation of PBL integrated with digital media requires teachers to design contextual problems, manage collaborative learning activities, and facilitate students' inquiry processes effectively. Teachers must also be capable of integrating digital tools meaningfully into learning activities rather than using technology solely as a supplementary component. Abdullah et al. (2025) emphasized that teacher readiness, instructional scaffolding, and classroom management play essential roles in determining the success of PBL implementation. In the present study, structured guidance and facilitation from the teacher helped students adapt to collaborative problem-solving activities and utilize digital media more effectively. This indicates that teacher competence in managing technology-enhanced learning environments is crucial for maximizing the effectiveness of Digital Media-Assisted PBL.

The duration of treatment also appears to influence the effectiveness of Digital Media-Assisted PBL in improving students' critical thinking skills. Yohannes et al. (2021) explained that longer implementation periods tend to produce stronger effects on students' mathematical critical thinking development. In the current study, the improvement observed in the experimental class suggests that consistent exposure to problem-solving activities and digital learning environments contributed to students' cognitive growth. Through repeated engagement in analytical reasoning and collaborative discussions, students gradually became more confident and skilled in evaluating mathematical information critically. Therefore, sustained and continuous implementation of Digital Media-Assisted PBL is recommended to achieve optimal learning outcomes in mathematics education.

Overall, the findings of this study indicate that Digital Media-Assisted Problem Based Learning is an effective instructional approach for improving junior high school students' mathematical critical thinking skills. The integration of digital media within the PBL framework created more interactive, contextual, and engaging learning experiences that encouraged students to participate actively in analytical reasoning and collaborative problem-solving activities. Compared to conventional learning methods, Digital Media-Assisted PBL provided greater opportunities for students to develop interpretation, analysis, evaluation, and inference skills during mathematics learning. These findings reinforce previous research highlighting the effectiveness of PBL and digital media integration in fostering higher-order thinking skills. Consequently, Digital Media-Assisted PBL can be considered a promising instructional strategy for supporting twenty-first century mathematics education and promoting student-centered learning environments that enhance critical thinking competencies among junior high school students.

5. CONCLUSION

In conclusion, the results of this study demonstrate that Digital Media-Assisted Problem Based Learning (PBL) has a positive and significant effect on junior high school students' mathematical critical thinking skills. Based on the research findings, the experimental class that received Digital Media-Assisted PBL achieved a higher posttest mean score (84.37) compared to the control class taught through conventional learning methods (72.15). Furthermore, the experimental class obtained an N-Gain score of 0.64, while the control class only achieved 0.38, indicating that the improvement in students' critical thinking skills was greater in the class implementing Digital Media-Assisted PBL. These findings indicate that the integration of digital media within the PBL framework successfully created more interactive, contextual, and student-centered learning experiences that encouraged students to analyze problems critically, evaluate information systematically, collaborate actively, and formulate logical conclusions during mathematics learning activities. Therefore, Digital Media-Assisted PBL can be considered an effective instructional strategy for improving students' mathematical critical thinking skills and supporting the development of higher-order thinking competencies required in twenty-first century education.

REFERENCES

Abdullah, O., Syaharuddin, S., Husain, H., Yasriuddin, Y., & Mendrofa, N. (2025). *Implementation of Problem-Based Learning to Enhance Critical Thinking Skills in Junior High School Students*. International Journal of Educational Research Excellence (IJERE). https://doi.org/10.55299/ijere.v4i1.1344

Aliza, N., H., Sudatha, G., Interaktif, P., & Masalah, B. (2024). *Interactive Multimedia with Problem-Based Learning in Mathematics*. Journal of Education Technology. https://doi.org/10.23887/jet.v7i4.64656

Amanda, N., & W. (2024). *Examining the Impact of Problem-Based Learning on Critical Thinking Among Junior High School Students*. International Journal of Curriculum Development, Teaching and Learning Innovation. https://doi.org/10.35335/curriculum.v2i2.161

Amiliya, F., & Ismiyanti, Y. (2025). *The Influence of Problem Based Learning with Interactive Media on Critical Thinking Skills*. BASICA. https://doi.org/10.37680/basica.v5i1.6923

Bintan, R., & Rahman, M. (2025). *Effectiveness of Problem-Based Learning Assisted by Digital Comic Media on Students' Critical Thinking*. Jurnal Profesi Keguruan. https://doi.org/10.15294/jpk.v11i1.26425

Cahayati, N., S., & Malawi, I. (2025). *Development of web-based learning media with Google Sites to improve critical thinking of junior high school students*. Jurnal Teori dan Praksis Pembelajaran IPS. https://doi.org/10.17977/um022v10i22025p98-114

Darmayanti, R., Sugianto, R., Baiduri, B., Choirudin, C., & Wawan, W. (2022). *Digital comic learning media based on character values on students' critical thinking in solving mathematical problems in terms of learning styles*. Al-Jabar: Jurnal Pendidikan Matematika. https://doi.org/10.24042/ajpm.v13i1.11680

Dewi, M., Hendriana, H., Supriatna, T., & Yuliani, A. (2025). *Enhanching Students' Mathematical Critical Thinking Skills through Google Sites-Assisted Problem Based Learning on Junior High School*. (JIML) Journal of Innovative Mathematics Learning. https://doi.org/10.22460/jiml.v8i2.23838

Fatih, M. (2025). *Interaction Problem Based Learning of AI Assisted on Digital Literacy and Critical Thinking Abilities*. Journal of Development Research. https://doi.org/10.28926/jdr.v9i1.452

Firmansyah, F., & Andriyani, A. (2023). *Developing Edpuzzle-assisted e-Worksheet to Enhance Students' Critical Thinking Skills in Problem-based Learning*. International Journal on Emerging Mathematics Education. https://doi.org/10.12928/ijeme.v7i2.29569

Fitriani, F., & K. (2022). *Mathematics Critical Thinking Skills of Third Grade Elementary School Students on Fractions*. MIMBAR PGSD Undiksha. https://doi.org/10.23887/jjpgsd.v10i3.48741

Harahap, A., Bentri, A., Musdi, E., Yerizon, Y., & Armiati, A. (2024). *Analysis of students' critical thinking skills in solving mathematics problems in terms of students' initial ability*. Indonesian Journal of Science and Mathematics Education. https://doi.org/10.24042/ijsme.v7i1.18014

Jihanifa, F., Sutopo, Y., Subali, B., & Widiarti, N. (2025). *Research Trend of Digital Learning Media in Science and Social Studies Based on Problem-Based Learning for Critical Thinking Skills (2020-2025)*. Journal of Innovation and Research in Primary Education. https://doi.org/10.56916/jirpe.v4i3.1410

Kanwal, S., Mahmood, W., Akram, M., & Pervez, N. (2024). *Effect of Critical Thinking Skills on Misconceptions of Students in Learning Mathematics at the Elementary School Level*. The Critical Review of Social Sciences Studies. https://doi.org/10.59075/dh559c79

Kartika, G., H., S., Arsyad, M., & M. (2025). *Interactive Digital Media Integration in Problem-Based Learning to Improve Critical Thinking Skills of Middle School Students*. Information Technology Education Journal. https://doi.org/10.59562/intec.v4i3.8584

Noris, M., Saputro, S., & M. (2023). *The development of problem based learning-based virtual laboratory media to improve critical thinking ability of junior high school students*. AIP Conference Proceedings. https://doi.org/10.1063/5.0147995

Pradana, K., & Noer, S. (2023). *Critical Thinking and Mathematical Problem Solving Skills of Students Through Schoology-Assisted Blended Learning Models*. Mathline: Jurnal Matematika dan Pendidikan Matematika. https://doi.org/10.31943/mathline.v8i3.455

Pramasdyahsari, A., Setyawati, R., Aini, S., Nusuki, U., Arum, J., Astutik, I., Widodo, W., Zuliah, N., & Salmah, U. (2023). *Fostering students' mathematical critical thinking skills on number patterns through digital book STEM PjBL*. Eurasia Journal of Mathematics, Science and Technology Education. https://doi.org/10.29333/ejmste/13342

Rahmawati, R., & Rizaldi, L. (2025). *Students' Mathematical Critical Thinking Skills and Difficulties in Solving Geometry Problems: An Analysis*. Jurnal Pendidikan Matematika (JPM). https://doi.org/10.33474/jpm.v11i2.24423

Romadhoni, S., Hakim, F., & Ningrum, L. (2025). *The Effectiveness of The Problem-Based Learning Model Assisted by Interactive Videos on Critical Thinking Skills*. Jambura Journal of Educational Chemistry. https://doi.org/10.37905/jjec.v7i1.27651

Susandi, A. (2021). *Critical Thinking Skills of Students in Solving Mathematical Problem*. Numerical: Jurnal Matematika dan Pendidikan Matematika. https://doi.org/10.25217/numerical.v5i2.1865

Utaminingsih, S., Amalia, I., & Sumaji, S. (2024). *Management of Mathematics Learning Based on Interactive Digital Worksheets to Improve Students' Critical Thinking Ability*. Journal of Curriculum and Teaching. https://doi.org/10.5430/jct.v13n1p159

Yohannes, Y., Juandi, D., & Tamur, M. (2021). *The Effect of Problem-Based Learning Model on Mathematical Critical Thinking Skills of Junior High School Students: A Meta-Analysis Study*. Jurnal Pengukuran Psikologi dan Pendidikan Indonesia (JP3I). https://doi.org/10.15408/jp3i.v10i2.17893