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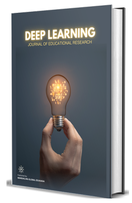

Improving Students' Critical Thinking Skills in Mathematics Learning by Using Interactive Multimedia

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ABSTRACT

This study aims to improve the critical thinking skills of elementary school students in mathematics learning by using interactive multimedia. This study is a classroom action research with the Kemmis & Mc Taggart model with four steps in each cycle, namely planning, action, observation and reflection. The subjects of this study were fifth-grade students of MIN 44 Aceh Besar. The data of this study were collected using observation and test techniques. Observation was used to obtain data on teacher and student learning activities, while tests were used to measure students' critical thinking skills in mathematics learning. The collected data were then analyzed using descriptive statistical techniques. The results of the study indicate that interactive multimedia can improve students' critical thinking skills in mathematics learning in elementary schools. This is evident from the results of the analysis of the research data which showed that the percentage of student completeness experienced a significant increase in each cycle with details of pre-cycle 52.19%, then increased in cycle 1 to 76.74% and in cycle 2 to 89.13%. The average value achieved also increased with details of pre-cycle 76.19, cycle 1 obtained 85.33 and cycle 2 obtained 91.47. Furthermore, the results of the standard deviation test also showed that the standard deviation value decreased in each cycle, indicating that students' critical thinking skills were becoming more evenly distributed. Based on these results, interactive multimedia can be used as an alternative learning medium to address students' low critical thinking skills in elementary school mathematics.

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Introduction

Critical thinking has increasingly been recognized as a fundamental competence that must be developed through formal education, particularly at the primary school level where foundational cognitive habits are formed. In the context of mathematics learning, critical thinking is not merely an additional skill, but an essential ability that enables students to interpret problems, analyze patterns, evaluate solutions, and make logical decisions. Mathematics is widely regarded as a discipline that naturally supports the development of higher-order thinking, yet in many educational settings students still experience mathematics as a subject that emphasizes memorization rather than reasoning.

The urgency of strengthening students' critical thinking skills is closely related to the demands of the twenty-first century, which require learners to be adaptive, analytical, and capable of solving complex problems. Education systems worldwide have shifted toward competency-based learning, emphasizing critical thinking, creativity, collaboration, and communication as key outcomes. These competencies are particularly important in mathematics because mathematical reasoning forms the basis for problem-solving in science, technology, and everyday decision-making (Trilling & Fadel, 2009; OECD, 2019).

Despite its importance, critical thinking remains one of the most challenging abilities to develop among elementary school students. Students often struggle to connect mathematical concepts with real-life contexts, resulting in superficial understanding and low reasoning performance. Many learners can solve routine questions but encounter difficulties when confronted with non-routine problems requiring justification, interpretation, and reflective reasoning. This phenomenon indicates that mathematics instruction still frequently prioritizes procedural fluency over conceptual understanding (Hiebert & Grouws, 2007; Lithner, 2008).

The development of critical thinking in mathematics learning is also closely linked to how students engage in cognitive processes during instruction. Students must be guided to question assumptions, interpret information, examine alternative strategies, and provide logical justification for their answers. When students are not provided with sufficient learning experiences that promote inquiry and reflection, their critical thinking development tends to stagnate. This condition is consistent with the argument that critical thinking is not an innate ability, but a skill that must be trained systematically through meaningful learning environments (Facione, 2011; Ennis, 2015).

Furthermore, mathematics learning in many primary schools is still dominated by teacher-centered approaches. Instruction is frequently delivered through explanation and demonstration, followed by repetitive exercises that focus on achieving correct answers. While this approach may improve short-term procedural performance, it often limits students' opportunities to explore reasoning, identify relationships, and evaluate strategies. As a result, students become passive recipients of information and tend to depend heavily on the teacher, which hinders the growth of independent thinking (Polya, 1973; NCTM, 2000).

Another major issue that influences students' low critical thinking performance is limited learning media and insufficient integration of technology in mathematics instruction. Traditional learning methods that rely mainly on textbooks and board explanations often fail to accommodate students' diverse learning styles and cognitive needs. Elementary students require learning experiences that are concrete, visual, and interactive in order to understand abstract mathematical concepts. When instruction lacks engaging learning tools, students may lose motivation and experience difficulty in sustaining attention during lessons (Mayer, 2009; Moreno & Mayer, 2007).

Technological integration in education has been widely identified as a strategic approach to address learning challenges in modern classrooms. Digital media provides opportunities to enhance learning engagement, improve comprehension, and facilitate higher-order thinking. Interactive technology, in particular, enables students to explore mathematical ideas dynamically through simulations, visual representations, and immediate feedback mechanisms. Such experiences support students' active learning processes and help them develop reasoning skills through exploration rather than passive reception (Clark & Mayer, 2016; Jonassen, 1999).

Interactive multimedia has emerged as one of the most promising digital learning resources for supporting effective instruction. Interactive multimedia refers to learning media that integrates text, images, animation, audio, and interactive elements that allow learners to actively participate in the learning process. This learning model provides opportunities for students to manipulate objects, respond to questions, and explore concepts through digital environments. These characteristics align with constructivist learning principles that emphasize active involvement and meaning-making (Mayer, 2005; Schunk, 2012).

From the perspective of cognitive learning theory, interactive multimedia can reduce cognitive overload and increase meaningful learning when designed properly. The Cognitive Theory of Multimedia Learning explains that students learn more effectively from words and pictures than from words alone because they process information through dual channels, namely visual and auditory channels. When multimedia content is designed based on cognitive principles, students can construct deeper understanding and improve their ability to analyze and interpret information (Mayer, 2009; Sweller, 2011).

In mathematics learning, the use of multimedia can help students understand abstract concepts through visualization and simulation. Mathematical topics that are difficult to grasp through verbal explanation can become more accessible when students interact with digital representations. Interactive multimedia enables students to observe patterns, test hypotheses, and evaluate outcomes through exploration. These learning experiences can strengthen critical thinking because students are encouraged to make predictions, identify relationships, and justify conclusions (Ainsworth, 2006; Hattie, 2009).

The relevance of multimedia integration is also supported by empirical research indicating that technology-based learning environments can improve students' critical thinking and problem-solving performance. Studies have found that interactive learning media enhances student engagement and supports deeper reasoning because it encourages exploration and reflection. Students who interact with multimedia tools tend to demonstrate higher learning motivation and improved learning outcomes compared to those who learn through conventional approaches (Sung, Chang, & Liu, 2016; Hillmayr et al., 2020).

In addition, interactive multimedia contributes to learning autonomy, which is an important element of critical thinking development. Students who learn through interactive platforms can control the pace of their learning, revisit content, and practice skills repeatedly until they achieve mastery. This self-regulated learning environment supports metacognitive development, which is closely linked to critical thinking because students learn to monitor their understanding, identify errors, and evaluate their own learning strategies (Zimmerman, 2002; Pintrich, 2004).

Critical thinking itself is often conceptualized as a process of analysis, evaluation, inference, and decision-making based on logical reasoning. In educational contexts, critical thinking is characterized by students' ability to interpret information, examine arguments, assess evidence, and generate justified conclusions. These abilities are essential in mathematics because mathematical reasoning requires logical thinking, evaluation of strategies, and validation of results through systematic procedures (Facione, 2011; Halpern, 2014).

In the Indonesian primary school context, mathematics achievement and reasoning skills remain a significant concern. International assessments such as PISA have consistently highlighted challenges in students' mathematical literacy, particularly in tasks that require reasoning and problem-solving. These results suggest that students struggle to apply mathematical knowledge to complex contexts, which reflects low critical thinking development. This condition indicates the need for instructional innovation that promotes reasoning-based learning rather than rote memorization (OECD, 2019; Stacey, 2011).

Moreover, the learning characteristics of elementary school students require instructional approaches that are engaging and developmentally appropriate. Children at this stage learn effectively through interactive activities, visual experiences, and contextual learning tasks. Therefore, instructional media that supports active engagement becomes an essential component of effective learning. Interactive multimedia is particularly suitable because it provides a learning environment that is both structured and stimulating for young learners (Piaget, 1970; Vygotsky, 1978).

The implementation of interactive multimedia in mathematics learning is also aligned with the integration of digital literacy in modern education. Digital literacy is not only about using technology but also about evaluating information, solving problems, and making decisions based on evidence. When students use interactive multimedia in mathematics, they are simultaneously exposed to digital learning experiences that encourage exploration and critical reflection. This integration supports the broader goal of preparing students to navigate information-rich environments in the digital era (Partnership for 21st Century Skills, 2015; Redecker, 2017).

However, the effectiveness of interactive multimedia depends on how it is implemented in classroom practice. Learning media cannot automatically improve students' critical thinking unless it is integrated with appropriate learning strategies. Teachers must design learning activities that encourage students to ask questions, test solutions, and discuss reasoning. Without reflective learning tasks, multimedia may only function as an entertaining tool rather than a cognitive learning resource (Bransford, Brown, & Cocking, 2000; Mishra & Koehler, 2006).

Teachers therefore play a crucial role in facilitating critical thinking-oriented learning through interactive multimedia. Educators must shift from being information transmitters to learning facilitators who guide students' reasoning processes. This approach requires teachers to provide opportunities for inquiry, encourage argumentation, and guide students in reflecting on problem-solving processes. Such teacher roles are central to effective mathematics instruction that promotes critical thinking development (Shulman, 1986; Darling-Hammond, 2017).

One systematic approach to improving instructional quality is classroom action research. Classroom action research allows teachers to implement interventions, observe outcomes, and refine instructional practices through cyclical processes. The Kemmis and McTaggart model is widely used in educational research because it provides structured steps of planning, action, observation, and reflection. This approach is effective for addressing real classroom problems and improving teaching practices through evidence-based improvements (Kemmis & McTaggart, 1988; Burns, 2010).

In mathematics learning, classroom action research is particularly relevant because it enables teachers to diagnose learning problems such as low reasoning performance and limited student engagement. Through action research, teachers can evaluate the effectiveness of interactive multimedia as an intervention and identify improvements in students' learning outcomes across cycles. This approach supports the continuous development of instructional quality and ensures that learning innovations are grounded in classroom realities (Creswell & Creswell, 2018; McNiff, 2013).

At MIN 44 Aceh Besar, preliminary observations indicated that students' critical thinking skills in mathematics were still relatively low. Students tended to rely on teacher explanations and experienced difficulty when asked to justify their answers or solve contextual problems. Such conditions demonstrate that students have not fully developed analytical and evaluative thinking abilities. This learning challenge requires an instructional solution that can increase student engagement and provide opportunities for active reasoning practice.

Considering these challenges, the integration of interactive multimedia is expected to provide an innovative learning environment that supports critical thinking development. Interactive multimedia can provide contextual tasks, visual representations, and interactive problem-solving experiences that encourage students to analyze and evaluate information. When students interact with learning materials actively, they can develop deeper conceptual understanding and strengthen their reasoning processes (Mayer, 2009; Jonassen, 1999).

Based on this rationale, this study focuses on the implementation of interactive multimedia as an instructional intervention to improve students' critical thinking skills in mathematics learning. The study applies a classroom action research design using the Kemmis and McTaggart model, which allows the researcher to evaluate improvements systematically across cycles. This research is expected to contribute to the development of innovative instructional practices, particularly in the context of elementary mathematics learning.

Therefore, the purpose of this study is to improve the critical thinking skills of fifth-grade students at MIN 44 Aceh Besar through the use of interactive multimedia in mathematics learning. This research is also expected to provide empirical evidence that interactive multimedia can serve as an alternative instructional medium to enhance students' reasoning abilities and learning outcomes. In addition, the findings may offer practical implications for teachers and schools in designing more effective mathematics instruction that supports higher-order thinking development.

Methods

This study employed a classroom action research design aimed at improving students' critical thinking skills in mathematics learning through the implementation of interactive multimedia. Classroom action research was selected because it is specifically designed to solve practical instructional problems that occur in real classroom contexts through systematic and reflective cycles. The research design followed the Kemmis and McTaggart model, which consists of four interconnected stages in each cycle, namely planning, action, observation, and reflection. This model was considered appropriate because it allows continuous improvement of instructional practices based on evidence collected during the learning process (Kemmis & McTaggart, 1988; Burns, 2010).

The research was conducted at MIN 44 Aceh Besar, Indonesia. This school was selected due to the identified instructional problem in mathematics learning, particularly the low level of students' critical thinking ability. The research setting reflected typical learning conditions in Indonesian primary schools, where mathematics instruction is still frequently dominated by teacher-centered approaches and limited use of technology-based learning media. The study was conducted during the second semester of the academic year, ensuring that students had already received prior exposure to the mathematics content and classroom routines relevant to the intervention.

The participants of this study were fifth-grade students at MIN 44 Aceh Besar. The selection of this class was based on preliminary observations and discussions with the classroom teacher indicating that students experienced difficulties in solving contextual mathematical problems requiring reasoning and justification. The class consisted of 23 students, including 12 male students and 11 female students. All students were included as research participants because classroom action research emphasizes improvement of collective classroom learning outcomes rather than sampling procedures. The classroom teacher also participated in this study as a collaborative partner, particularly in assisting the implementation of learning activities and providing reflective feedback after each cycle (McNiff, 2013; Creswell & Creswell, 2018).

The primary focus of the intervention was the integration of interactive multimedia into mathematics instruction. Interactive multimedia in this study referred to a digital learning resource that combined text, images, animations, audio explanations, and interactive problem-based exercises. The multimedia was designed to encourage active engagement and cognitive processing through tasks that required students to analyze information, evaluate possible strategies, and provide justification for their answers. The multimedia content was developed in alignment with the mathematics curriculum for grade five and was adapted to the students' learning characteristics. The design of multimedia activities followed multimedia learning principles emphasizing coherence, signaling, and interactivity to support meaningful learning and reduce cognitive overload (Mayer, 2009; Clark & Mayer, 2016).

The mathematics topic selected for the intervention was adjusted to the teaching schedule and curriculum demands at MIN 44 Aceh Besar. The learning materials included conceptual explanation, worked examples, interactive simulations, and contextual word problems. Each interactive task was intentionally structured to stimulate students' critical thinking processes, such as identifying given information, interpreting the meaning of mathematical statements, analyzing relationships between numbers, and evaluating solution strategies. This approach was consistent with the view that critical thinking can be improved through problem-based learning tasks that require reasoning and reflection (Facione, 2011; Ennis, 2015).

The research procedure was conducted in three main phases, consisting of pre-cycle activities, Cycle I implementation, and Cycle II implementation. The pre-cycle phase aimed to identify the initial condition of students' critical thinking ability and classroom learning activities before the intervention. During this stage, the teacher conducted mathematics instruction using conventional teaching methods typically applied in the classroom. At the end of the pre-cycle phase, students were given an initial critical thinking test to measure baseline performance. The results of the pre-cycle assessment served as a reference point for determining improvements across the subsequent cycles.

Cycle I began with the planning stage, in which the researcher and classroom teacher collaboratively prepared lesson plans, interactive multimedia learning materials, student worksheets, observation sheets, and assessment instruments. The lesson plan was designed based on the Indonesian primary school curriculum and incorporated interactive multimedia as the main learning medium. In addition, the researcher developed classroom management strategies to ensure that students could effectively interact with the multimedia materials, including technical preparation such as the use of projectors, speakers, and student access to the multimedia content. The planning stage also included the preparation of learning objectives focusing on critical thinking indicators, such as interpretation, analysis, evaluation, and inference in solving mathematical problems (Facione, 2011; Halpern, 2014).

The action stage of Cycle I involved the implementation of interactive multimedia in the classroom. Learning activities were conducted through three structured phases, namely introduction, core learning activities, and closure. In the introduction stage, the teacher provided motivation, explained the learning objectives, and activated students' prior knowledge through short questions related to daily mathematical contexts. In the core activities, students were introduced to interactive multimedia content, which presented conceptual explanations and problem-solving demonstrations through animations and guided examples. Students were encouraged to actively respond to questions embedded within the multimedia, discuss their answers, and justify their reasoning. The teacher facilitated classroom discussion, guided students' exploration, and ensured that students remained engaged with the tasks.

During Cycle I, students were also given opportunities to solve interactive exercises presented in the multimedia. These exercises included multiple-choice questions, short-answer reasoning tasks, and contextual word problems. Students were required to explain their reasoning either orally or in written form. This instructional approach aimed to shift students' learning behavior from passive listening to active thinking and reasoning. The interactive multimedia environment was expected to support student engagement and conceptual understanding through visualization and immediate feedback mechanisms (Mayer, 2009; Sung et al., 2016).

At the end of Cycle I, students completed a critical thinking test designed to evaluate their progress. The test consisted of problem-based questions requiring students to analyze information, identify appropriate strategies, and provide logical explanations for their solutions. The results of the Cycle I test were compared with pre-cycle results to determine improvements in critical thinking performance.

The observation stage was conducted simultaneously with the action stage. Observations were carried out by the researcher using structured observation sheets focusing on teacher and student learning activities. Teacher activity observation aimed to assess instructional performance, including lesson delivery, facilitation of interactive multimedia use, classroom management, questioning strategies, and feedback provision. Student activity observation focused on student engagement indicators such as attention, participation in discussion, responsiveness to multimedia tasks, ability to ask questions, and collaboration with peers. Observation data were collected systematically during each learning session to ensure accurate documentation of learning behavior (Burns, 2010; Creswell & Creswell, 2018).

The reflection stage of Cycle I involved analysis of the observation results and students' test performance. The researcher and teacher collaboratively identified strengths and weaknesses in the learning implementation. Reflection was conducted to determine whether the intervention successfully improved student engagement and critical thinking skills, and to identify aspects that needed improvement for the next cycle. During reflection, the researcher analyzed student difficulties, such as misconceptions, low participation in discussion, and challenges in interpreting contextual problems. The reflection stage served as the basis for revising instructional strategies and multimedia utilization in Cycle II.

Cycle II followed the same four stages but incorporated improvements based on Cycle I reflection results. In the planning stage of Cycle II, lesson plans were revised by enhancing the clarity of instructions, increasing opportunities for student discussion, and strengthening scaffolding strategies. The interactive multimedia materials were also adjusted by adding more contextual examples, improving visual explanations, and providing additional interactive tasks that required justification. These revisions aimed to enhance students' reasoning processes and reduce confusion during learning. The improvement process aligned with the principle that classroom action research is a cyclical effort to refine teaching practices and achieve higher learning outcomes (Kemmis & McTaggart, 1988; McNiff, 2013).

The action stage of Cycle II emphasized deeper student engagement in reasoning-based problem solving. The teacher encouraged students to explain their thought processes more explicitly and provided guided questions to stimulate analysis and evaluation. Students were also encouraged to compare alternative solution strategies and identify the most efficient approach. In addition, group discussion was strengthened to allow students to exchange ideas and justify their reasoning collaboratively. Such collaborative reasoning activities were considered essential for developing critical thinking because students learn to evaluate arguments and improve their understanding through peer interaction (Vygotsky, 1978; Darling-Hammond, 2017).

The observation stage of Cycle II was conducted using the same observation instruments as Cycle I. The researcher documented improvements in teacher instructional behavior and student learning participation. Observations also focused on whether students showed increased independence in interacting with multimedia tasks and whether they demonstrated improved ability to interpret and evaluate mathematical problems.

At the end of Cycle II, students completed a final critical thinking test similar in structure and difficulty level to the previous tests. The results of this test served as the primary indicator of the effectiveness of the intervention. Students' scores were analyzed to determine improvements in average performance, learning mastery percentage, and score distribution consistency across cycles.

Data in this study were collected using two main techniques, namely observation and testing. Observation was used to collect qualitative-quantitative data regarding teacher and student learning activities during the implementation of interactive multimedia. Observation sheets were developed in the form of structured rating scales to ensure objectivity and consistency. Each indicator was rated using a four-level performance scale, ranging from poor to excellent. The observation instruments were validated through expert review by senior teachers and educational researchers to ensure content relevance and clarity (Creswell & Creswell, 2018; Fraenkel, Wallen, & Hyun, 2019).

Testing was used to measure students' critical thinking skills in mathematics learning. The critical thinking test was designed based on critical thinking indicators adapted from established theoretical frameworks. The test items were structured to measure students' ability to interpret mathematical problems, analyze relationships between given information, evaluate strategies, and draw conclusions. The test included both structured problem-solving questions and contextual word problems requiring written justification. The test was administered at three points: pre-cycle, after Cycle I, and after Cycle II. Test validity was examined through content validation conducted by mathematics education experts, ensuring that the items aligned with learning objectives and critical thinking indicators (Facione, 2011; Ennis, 2015).

To ensure the reliability and credibility of the data, triangulation was applied by comparing observation findings with test results. This approach strengthened the trustworthiness of the conclusions because improvements in student critical thinking performance were supported by both behavioral engagement evidence and quantitative achievement data. Additionally, consistent observation procedures were maintained across cycles to reduce measurement bias and ensure comparability of results.

Data analysis in this study employed descriptive statistical techniques. Students' test scores were analyzed to determine mean scores, mastery learning percentages, and standard deviation values across pre-cycle, Cycle I, and Cycle II. The mastery learning percentage was calculated by dividing the number of students who achieved the minimum mastery criterion by the total number of students and multiplying by 100 percent. The minimum mastery criterion (KKM) used in this study was determined based on school policy, which was set at 75. Mean scores were calculated to identify general improvement in student performance, while standard deviation values were analyzed to examine score distribution and consistency. A decreasing standard deviation across cycles was interpreted as an indicator that students' critical thinking skills became more evenly distributed among the class.

Observation data were analyzed descriptively by calculating the percentage of teacher and student activity performance in each cycle. The observation scores were converted into percentages to determine whether classroom activity improved after the implementation of interactive multimedia. The results were interpreted using predetermined criteria, where higher percentages indicated more effective learning implementation and stronger student engagement. These observation results were used as supporting evidence to interpret test score improvements.

Ethical considerations were carefully addressed throughout the study. Permission to conduct the research was obtained from the school principal and classroom teacher. Students' participation was treated as part of normal classroom learning improvement, and no harmful procedures were applied. The collected data were used solely for research purposes and were reported in aggregated form to protect student identity and privacy. The intervention was also designed to ensure that all students benefited equally from the learning improvement process, consistent with ethical principles in educational research (Cohen, Manion, & Morrison, 2018).

Result

This section presents the findings of the classroom action research conducted in three phases, namely pre-cycle, Cycle I, and Cycle II. The results focus on the improvement of students' critical thinking skills in mathematics learning after the implementation of interactive multimedia. The analysis is based on students' achievement scores, mastery learning percentages, and score distribution as indicated by standard deviation values. In addition, the results of teacher and student learning activity observations are also described to strengthen the interpretation of the intervention outcomes.

The pre-cycle results reflected the initial condition of students' critical thinking ability before the use of interactive multimedia. At this stage, mathematics learning was still dominated by conventional instruction, where the teacher explained the material and students mainly followed procedural examples. Based on the initial test, it was found that the overall achievement level of students' critical thinking skills was relatively low. Many students were only able to answer routine questions and had difficulty solving contextual problems requiring reasoning, justification, and analysis.

After the implementation of interactive multimedia in Cycle I, students showed significant improvement in their ability to interpret mathematical problems and apply problem-solving strategies. However, the observation results indicated that several students were still hesitant to provide detailed explanations of their reasoning. Some students were able to reach correct answers but were not yet consistent in describing the logic behind their solutions. This indicated that the intervention began to stimulate higher-order thinking, but deeper critical reasoning still required improvement.

The results in Cycle II demonstrated stronger improvement compared to Cycle I. Students not only achieved higher test scores, but also demonstrated more stable performance distribution. They were increasingly able to explain mathematical reasoning, evaluate strategies, and provide logical conclusions. This improvement indicated that the interactive multimedia intervention became more effective after instructional refinement in Cycle II. To provide a clearer representation of the findings, the descriptive statistics of students' critical thinking test scores are presented in Table 1.

Table 1. Students' Critical Thinking Achievement Across Research Phases

Research Phase	Mean Score	Mastery Percentage (%)	Standard Deviation
Pre-cycle	76.19	52.19	12.47
Cycle I	85.33	76.74	8.91
Cycle II	91.47	89.13	5.62

The data in Table 1 shows a consistent upward trend in students' critical thinking achievement. In the pre-cycle phase, the mean score was 76.19, indicating that students' general performance was slightly above the minimum mastery criterion (75). However, despite the mean score meeting the minimum standard, only 52.19% of students achieved mastery learning. This finding suggests that the learning outcomes were not evenly distributed and that a considerable number of students still experienced difficulty solving critical thinking-oriented mathematics problems.

The standard deviation in the pre-cycle phase was 12.47, which indicates a wide variation in students' performance. This suggests that there was a significant gap between high-achieving and low-achieving students. Several students were able to demonstrate adequate reasoning skills, while others struggled substantially in interpreting and analyzing problems. This uneven distribution reflects that the learning process before the intervention was not fully effective in supporting all students equally.

In Cycle I, the mean score increased to 85.33. This improvement indicates that students demonstrated better understanding and stronger reasoning ability after the implementation of interactive multimedia. The mastery learning percentage also increased significantly from 52.19% to 76.74%. This finding suggests that interactive multimedia helped a larger number of students achieve the learning objectives and improved their ability to solve reasoning-based mathematics problems.

The standard deviation in Cycle I decreased to 8.91. This reduction indicates that students' performance became more consistent and the achievement gap between students decreased. This result supports the interpretation that interactive multimedia not only improved average achievement but also facilitated learning equity by helping lower-achieving students improve their understanding through visual explanations and interactive practice.

In Cycle II, the improvement became more substantial. The mean score increased to 91.47, showing that students reached a higher level of mastery in mathematics reasoning tasks. The mastery learning percentage increased to 89.13%, which indicates that the majority of students were able to meet the learning objectives. This result suggests that the instructional refinement conducted after Cycle I reflection contributed positively to learning effectiveness.

The standard deviation in Cycle II further decreased to 5.62. This indicates that students' achievement distribution became more uniform. The decreasing standard deviation is a strong indicator that students' critical thinking skills improved not only in terms of higher scores but also in terms of more consistent competence among students. The intervention therefore succeeded in reducing learning disparities and ensuring that a larger number of students reached similar performance levels.

In addition to test score data, the results of teacher and student learning activity observations also supported the effectiveness of the intervention. During the pre-cycle phase, observation results indicated that teacher activity was mainly limited to explaining concepts and providing examples, while students were passive and less engaged in discussion. Many students only followed instructions without actively questioning or exploring alternative solutions.

In Cycle I, teacher activity improved as the teacher began facilitating interactive multimedia use and encouraged students to respond to embedded questions within the multimedia. Students demonstrated higher engagement compared to the pre-cycle phase. They were more attentive and showed increased participation in responding to interactive tasks. However, observation notes indicated that some students still relied on teacher guidance and were not fully confident in expressing their reasoning.

In Cycle II, teacher facilitation became more structured, and questioning strategies were more focused on stimulating analysis and evaluation. Students became more active in participating in classroom discussions and were increasingly able to explain the logic behind their solutions. Students also showed improved ability to evaluate their own answers by comparing them with multimedia feedback and peer explanations. This indicates that the learning environment became more reflective and reasoning-oriented.

The results clearly demonstrate that interactive multimedia was effective in improving students' critical thinking skills in mathematics learning. This effectiveness was evidenced by increased mean scores, improved mastery learning percentages, and reduced standard deviation values, indicating both achievement improvement and stronger learning equity.

Discussion

The findings of this study indicate that interactive multimedia significantly improved fifth-grade students' critical thinking skills in mathematics learning. The improvement was observed not only in increased mean test scores but also in higher mastery learning percentages and decreasing standard deviation values. This pattern demonstrates that interactive multimedia supported both overall learning improvement and greater consistency in students' critical thinking performance.

The pre-cycle results revealed that students' critical thinking ability was relatively weak, as indicated by the low mastery percentage of 52.19%. Although the mean score was slightly above the minimum mastery criterion, the high standard deviation indicated that many students still struggled to solve reasoning-oriented problems. This finding is consistent with research indicating that traditional mathematics instruction often emphasizes procedural practice rather than conceptual reasoning, resulting in students being able to answer routine tasks but failing to solve contextual and analytical problems (Hiebert & Grouws, 2007; Lithner, 2008).

The implementation of interactive multimedia in Cycle I led to a significant improvement in students' performance, with the mean score increasing from 76.19 to 85.33 and mastery learning improving to 76.74%. This improvement suggests that interactive multimedia facilitated better conceptual understanding and enhanced students' ability to interpret mathematical problems. This result aligns with the Cognitive Theory of Multimedia Learning, which states that students learn more effectively when information is presented through both verbal and visual channels, enabling deeper cognitive processing and stronger retention (Mayer, 2009; Moreno & Mayer, 2007).

The improvement in Cycle I can also be explained through constructivist learning theory, which emphasizes that knowledge is actively constructed through interaction and experience. Interactive multimedia provided students with opportunities to explore mathematical concepts through animations, simulations, and interactive exercises. These features supported active learning, allowing students to engage in problem-solving activities rather than passively receiving information. This learning process is critical for developing reasoning skills because students must actively interpret, analyze, and apply concepts to solve tasks (Piaget, 1970; Schunk, 2012).

Furthermore, the decrease in standard deviation from 12.47 in the pre-cycle phase to 8.91 in Cycle I indicates that students' performance became more evenly distributed. This suggests that interactive multimedia played an important role in supporting lower-achieving students. Visual explanations and guided interactive tasks likely helped students who previously struggled with abstract mathematical concepts. This finding is consistent with previous research showing that technology-enhanced learning environments can reduce learning disparities by providing more accessible representations and immediate feedback for students (Sung et al., 2016; Hillmayr et al., 2020).

Despite the improvement in Cycle I, reflection results indicated that some students were still not fully confident in explaining their reasoning. This phenomenon suggests that while interactive multimedia improved comprehension and engagement, students still needed stronger scaffolding to develop deeper evaluative and inferential thinking. This finding supports the argument that critical thinking does not develop automatically through exposure to learning media, but requires guided instructional strategies that encourage students to justify, evaluate, and reflect on their reasoning processes (Facione, 2011; Ennis, 2015).

After revising the instructional approach in Cycle II, the results improved further, with the mean score increasing to 91.47 and mastery learning reaching 89.13%. This substantial improvement indicates that the refinement of teaching strategies and multimedia integration enhanced the effectiveness of the intervention. The learning process in Cycle II emphasized deeper questioning, structured discussion, and explicit reasoning tasks. This improvement aligns with the view that teacher facilitation plays a crucial role in maximizing the effectiveness of digital learning tools (Mishra & Koehler, 2006; Darling-Hammond, 2017).

The significant improvement in Cycle II also reflects the role of scaffolding in developing critical thinking skills. In this cycle, the teacher guided students to interpret problems systematically, compare alternative strategies, and justify conclusions. This structured support enabled students to gradually develop independent reasoning ability. The importance of scaffolding is emphasized in sociocultural theory, which argues that students develop higher cognitive skills through guided interaction within their zone of proximal development (Vygotsky, 1978; Bransford et al., 2000).

Another important finding is the decreasing standard deviation in Cycle II, which reached 5.62. This indicates that students' critical thinking performance became more stable and uniform. This pattern suggests that the majority of students developed similar levels of reasoning competence after the intervention. The reduction in score variation is an important outcome because it demonstrates that interactive multimedia not only improved high-achieving students but also effectively supported students who initially performed at lower levels. This outcome supports the argument that interactive multimedia can contribute to more equitable learning opportunities when implemented with appropriate instructional guidance (OECD, 2019; Hattie, 2009).

The increased mastery percentage in Cycle II also indicates that interactive multimedia supported meaningful learning. Meaningful learning occurs when students actively connect new information with prior knowledge and apply it in problem-solving contexts. The multimedia content in this study presented contextual tasks and visual representations that helped students link mathematical concepts with real-life situations. This learning environment encouraged students to interpret problems more deeply rather than relying solely on memorization. Such meaningful learning experiences are essential for critical thinking development because they require students to analyze information, evaluate evidence, and draw logical conclusions (Jonassen, 1999; Halpern, 2014).

In addition, interactive multimedia provided immediate feedback through interactive exercises. This feedback mechanism likely contributed to students' improved reasoning because it allowed them to recognize errors, revise strategies, and confirm correct understanding. Feedback is widely recognized as a key factor influencing learning improvement because it supports metacognitive regulation and helps students monitor their own progress (Hattie & Timperley, 2007; Zimmerman, 2002). In mathematics learning, immediate feedback is particularly important because it strengthens students' confidence and encourages them to explore alternative approaches.

The findings of this study also highlight the importance of student engagement in improving critical thinking performance. Observation results indicated that students became more active and attentive during interactive multimedia sessions. Increased engagement likely contributed to improved learning outcomes because engaged students tend to invest more cognitive effort in analyzing and solving tasks. This result supports the argument that learning motivation and engagement are strongly associated with cognitive achievement, particularly in problem-solving and reasoning-based learning (Fredricks, Blumenfeld, & Paris, 2004; Schunk, 2012).

The improvement of critical thinking skills observed in this study also reflects the relevance of multimedia learning principles. The interactive multimedia used in this research combined text explanations, animations, and audio guidance, which likely enhanced students' cognitive processing. According to multimedia learning theory, the integration of words and visuals facilitates deeper understanding because learners can construct mental representations more effectively. This is particularly relevant for mathematics learning, where abstract concepts often require visualization to be fully understood (Mayer, 2009; Ainsworth, 2006).

Moreover, interactive multimedia encouraged exploratory learning, which is essential for critical thinking development. Students were not limited to a single explanation but could observe different representations, test strategies, and compare results. This process supports analytical thinking because students learn to examine relationships and evaluate outcomes. Such exploratory learning aligns with the principles of inquiry-based learning, which emphasizes student investigation and reasoning as central learning processes (NCTM, 2000; Bransford et al., 2000).

The results of this study are also consistent with previous findings showing that technology-enhanced learning can significantly improve mathematics learning outcomes. Hillmayr et al. (2020) found that digital learning tools have positive effects on mathematics achievement, particularly when they support active engagement and interactive practice. Similarly, Sung et al. (2016) reported that technology integration improves learning performance by increasing motivation and providing more flexible learning experiences. The present study strengthens these findings by demonstrating that interactive multimedia can specifically enhance critical thinking, as reflected in improved mastery percentages and reduced score variation.

In the Indonesian educational context, improving critical thinking skills is crucial because international assessments have highlighted students' low performance in mathematical literacy and reasoning tasks. The improvement observed in this study suggests that interactive multimedia can serve as an effective instructional innovation to address this challenge. By providing contextual problems, visual representations, and interactive reasoning tasks, multimedia learning environments can help students develop competencies required for higher-order thinking and problem-solving, which are increasingly emphasized in global educational standards (OECD, 2019; Stacey, 2011).

The findings also imply that classroom action research is an effective approach for improving teaching practices. Through the cyclical process of planning, action, observation, and reflection, the teacher was able to identify instructional weaknesses in Cycle I and refine strategies in Cycle II. This continuous improvement process contributed to better learning outcomes and stronger student reasoning performance. This result supports the view that action research provides practical and systematic opportunities for teachers to enhance instructional quality based on evidence collected directly from classroom practice (Kemmis & McTaggart, 1988; McNiff, 2013).

Although the results demonstrate strong improvement, it is important to acknowledge that the success of interactive multimedia depends on teacher facilitation and instructional design. Multimedia tools must be integrated with structured questioning, collaborative discussion, and reasoning-oriented tasks to effectively stimulate critical thinking. Without these elements, multimedia may function merely as a presentation tool rather than a cognitive learning resource. Therefore, the teacher's pedagogical competence remains a crucial factor in ensuring the success of multimedia-based learning interventions (Mishra & Koehler, 2006; Darling-Hammond, 2017).

Conclusion

This classroom action research confirms that the integration of interactive multimedia in mathematics learning is effective in improving elementary school students' critical thinking skills. The findings demonstrated a consistent and significant increase in students' learning outcomes across the research phases, as reflected in the improvement of mastery learning percentage from 52.19% in the pre-cycle to 76.74% in Cycle I and 89.13% in Cycle II, accompanied by an increase in mean scores from 76.19 to 85.33 and finally 91.47. Furthermore, the decreasing standard deviation across cycles indicates that students' critical thinking abilities became more evenly distributed, suggesting that interactive multimedia not only enhanced overall achievement but also contributed to reducing learning gaps among students. These results highlight that interactive multimedia, when implemented through systematic planning, reflective teaching practice, and structured classroom facilitation, can serve as an effective instructional alternative for promoting higher-order thinking in elementary mathematics education, particularly in strengthening students' analytical reasoning, evaluation skills, and problem-solving competence.

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