Journal of Frontiers in Multidisciplinary Research

The Use of Multimodal Media to Improve Critical Thinking Skills in Mathematics Learning for Elementary School Students

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Article Info

E-ISSN: 3050-9726
P-ISSN: 3050-9718
Impact Factor (RSIF): 7.34
Volume: 07
Issue: 01
Received: 18-03-2026
Accepted: 17-04-2026
Published: 16-05-2026
Page No: 445-449

Abstract
This study aimed to examine the effectiveness of multimodal media based on Interactive Flat Panel (IFP) in improving elementary school students' critical thinking skills in mathematics learning. The study employed a classroom action research (CAR) design using a mixed qualitative–quantitative approach conducted in two cycles, consisting of planning, action, observation, and reflection stages. The participants were 30 second-grade students of SDN Singopuran 03. Data were collected through critical thinking tests, observations, and documentation. The assessment of critical thinking skills referred to Facione's indicators, including interpretation, analysis, evaluation, inference, and explanation. Quantitative data were analyzed descriptively through mean scores and learning mastery percentages, while qualitative data were analyzed from classroom observations and reflective notes. The findings revealed a significant improvement in students' critical thinking skills after the implementation of multimodal media based on IFP. The average critical thinking score increased from 65.60 in Cycle I to 80.28 in Cycle II, with an overall improvement of 14.68 points. Learning mastery also increased from 60.00% in Cycle I to 86.67% in Cycle II. In addition, students' learning activities improved from the "fair" category to the "good" category, particularly in questioning, discussion participation, expressing opinions, and problem-solving abilities. The most notable improvements were found in the analysis and explanation indicators, indicating that students became more capable of analyzing mathematical problems and communicating logical reasoning systematically. The study concludes that multimodal media based on Interactive Flat Panel (IFP) effectively enhances students' critical thinking skills and learning engagement in elementary mathematics learning. The integration of visual, symbolic, contextual, and interactive representations creates a richer learning experience that supports the development of higher-order thinking skills in 21st-century education.

DOI: https://doi.org/10.54660/.JFMR.2026.7.1.445-449

Keywords: Multimodal Media, Interactive Flat Panel (IFP), Critical Thinking Skills, Mathematics Learning, Elementary School Students

Introduction

Twenty-first century education requires a shift in the learning paradigm from merely transferring knowledge to developing higher-order thinking skills (HOTS). These skills include critical thinking and creative thinking, which are essential for addressing the complex and dynamic challenges of modern life (Partnership for 21st Century Skills, 2019) [13].

The Merdeka Curriculum emphasizes the use of varied, contextual, and student-centered learning media to encourage active engagement and the development of thinking skills. However, in practice at the elementary school level, instruction is still dominated by conventional media such as textbooks and worksheets, which tend to be one-way and procedural. This condition limits opportunities for students to explore, analyze, and reflect on knowledge in depth (Miswanto, 2022) [8]. Research by Azhari & Akmam (2025) [1] indicates that the use of static and less interactive media remains a common practice in classrooms, and therefore has not been able to accommodate students' diverse learning styles or higher-order thinking needs.

The impact of this condition is reflected in the low thinking ability of Indonesian students. The results of the 2022 Programme for International Student Assessment (PISA), conducted by the Organization for Economic Co-operation and Development, show that Indonesian students' mathematical literacy score was 379, far below the OECD average of approximately 472. In addition, most Indonesian students only reached Levels 1 and 2, indicating that they still experience difficulties in solving problems that require complex reasoning and non-routine problem solving (OECD, 2023) [12].

Mathematics is one of the subjects that plays an important role in developing students' critical and creative thinking skills. Through mathematics learning, students are trained to understand concepts, analyze problems, and find solutions logically and systematically (National Council of Teachers of Mathematics [NCTM], 2000) [11]. The results of the Trends in International Mathematics and Science Study (TIMSS) 2019, conducted by the International Association for the Evaluation of Educational Achievement, show that Indonesian students' mathematics score was 397, which is also below the international average of 500 (Mullis *et al*., 2020) [9]. These data indicate that students still experience difficulties in solving problems that require complex reasoning and critical thinking. Research by Sunanto *et al*. (2025) [16] shows that elementary school students' mathematical critical thinking skills remain in the low to moderate category and require more innovative instructional interventions.

Field evidence shows that the critical and creative thinking skills of elementary school students in Kartasura District, Sukoharjo Regency, particularly in lower grades, have not yet developed optimally. Students tend to memorize problem-solving procedures without understanding the underlying concepts. In addition, they experience difficulties when confronted with non-routine problems that require reasoning and creativity. Students tend to rely on memorized procedures rather than deep conceptual understanding. They also struggle with open-ended problems that demand flexible and innovative thinking skills.

One of the factors contributing to this issue is the limited availability of learning media that can optimally facilitate students' thinking processes. Research by Muti *et al*. (2024) [10] shows that the use of interactive digital learning media, such as multimedia, e-books, and interactive applications, has proven to be more effective in improving critical thinking skills because it provides visualization, interactivity, and deeper learning experiences. Furthermore, technology-based media such as augmented reality and other interactive media have also been shown to enhance both motivation and critical thinking skills in elementary mathematics learning (Fatmaningrum & Jazuli, 2025) [5].

As an effort to overcome these limitations, the use of multimodal media based on Interactive Flat Panels (IFP) is considered a relevant alternative. An IFP is an interactive digital display device that allows the integration of various forms of media, such as text, images, videos, animations, and interactive activities within a single display (Indrasari & Inganah, 2025) [6]. Through IFPs, teachers can present mathematics content in a more visual and contextual manner, for example by displaying illustrations, simulations, and problem-based stories that students can respond to directly through touch interaction (Farihah *et al*., 2025) [4]. Thus, learning is no longer one-way, but becomes more interactive and encourages students to observe, analyze, and explore concepts in greater depth. This approach is expected to support the development of students' critical thinking skills more optimally.

This approach is consistent with the findings of Setyo & Layn (2025) [15], who reported that the use of multimodal media, such as interactive flipbooks and interactive digital narratives, can improve critical thinking skills by enabling students to construct knowledge through multiple representations of information simultaneously. For example, mathematical concepts such as fractions can be presented through visual illustrations (e.g., slices of cake), contextual stories, and symbolic representations at the same time. This process encourages students to compare, interpret, and evaluate information, which are core components of critical thinking (Facione, 2015) [3]. Research by Jihanifa *et al*. (2025) [7] also demonstrates that the integration of various forms of media (visual, narrative, and interactive) not only enhances conceptual understanding but also significantly strengthens students' analytical, reflective, and problem-solving abilities.

Nevertheless, empirical studies that specifically examine the effectiveness of multimodal media in mathematics learning at the elementary school level remain limited. Most previous studies have focused more on instructional models (such as problem-based learning and discovery learning) or the partial use of digital media, without comprehensively integrating multiple modes (text, visuals, and narratives) into a unified learning medium. As a result, research that directly investigates the influence of multimodal media on elementary school students' critical thinking skills in mathematics learning is still insufficient.

Based on the foregoing discussion, this study aims to examine the effectiveness of using multimodal media in mathematics learning to improve elementary school students' critical thinking skills. This study is expected to contribute theoretically to the development of multimodal-based learning research and practically by providing an innovative alternative learning medium that aligns with the demands of twenty-first century education.

Method

This study employed a qualitative-quantitative approach using Classroom Action Research (CAR). CAR was selected because it aims to directly improve and enhance the quality of classroom instruction through the implementation of multimodal media based on Interactive Flat Panels (IFP), particularly in improving students' critical thinking skills in mathematics learning.

The study was conducted in Grade 2 of SDN Singopuran 03 with a total of 30 students as research subjects. The research was carried out in two cycles, with each cycle consisting of four stages: (1) planning, (2) action, (3) observation, and (4) reflection.

During the planning stage, the researcher prepared instructional materials, including multimodal teaching modules utilizing IFP, student worksheets, and assessment instruments to measure critical thinking skills. The action stage involved implementing mathematics instruction using IFP-based multimodal media in the classroom. During the observation stage, the researcher observed students' activities, engagement in the learning process, and the development of their critical thinking skills using prepared observation sheets. The reflection stage was conducted to evaluate the outcomes of each cycle and to serve as the basis

for improvements in the subsequent cycle.

Data collection techniques in this study included tests, observations, and documentation. Tests were used to measure students' critical thinking skills before and after the intervention, while observations were conducted to examine students' activities and engagement during the learning process. Documentation was used to complement the research data in the form of activity photographs and instructional records.

Critical thinking skills in this study were measured based on the indicators proposed by Facione (2015), which include:

1. Interpretation, namely the ability to understand and explain the meaning of the information or problems presented;
2. Analysis, namely the ability to identify relationships among concepts and break down problems into simpler components;
3. Evaluation, namely the ability to assess the validity of information or the problem-solving strategies used;
4. Inference, namely the ability to draw logical conclusions based on available data or facts; and
5. Explanation, namely the ability to present reasons or arguments clearly and systematically.

These five indicators served as the basis for developing the test instruments and observation sheets used to measure the development of students' critical thinking skills in each cycle. The collected data were analyzed using descriptive quantitative and qualitative techniques. Quantitative analysis was conducted by calculating the mean scores and the percentage of students achieving mastery learning in each cycle, while qualitative analysis was conducted based on the results of student activity observations and instructional reflections. The success indicators of the study were determined based on improvements in students' critical thinking skills in each cycle and the achievement of the predetermined minimum mastery criteria.

Results

This study aimed to improve students' critical thinking skills through the use of multimodal media based on Interactive Flat Panels (IFP) in mathematics learning. The research findings were obtained through the implementation of two cycles of Classroom Action Research (CAR), which included the measurement of critical thinking skills, learning mastery, and student activities during the learning process. The results are presented in the following tables.

Table 1: Students' Critical Thinking Skills in Each Cycle

No	Critical Thinking Indicator (Facione)	Cycle I (Mean)	Cycle II (Mean)	Category	Improvement
1	Interpretation	68,40	82,10	Good	13,70
2	Analysis	65,20	80,50	Good	15,30
3	Evaluation	63,80	78,60	Good	14,80
4	Inference	64,50	79,20	Good	14,70
5	Explanation	66,10	81,00	Good	14,90
	Mean	65,60	80,28	Good	14,68

The table above shows that students' critical thinking skills improved gradually from the initial condition to Cycle I and Cycle II. In the initial condition, students' scores were still in the low to fair range, with a class average of approximately 57–60. This indicates that most students had not yet been able to interpret, analyze, and evaluate mathematical problems optimally.

After the implementation of mathematics instruction using IFP-based multimodal media in Cycle I, the class average increased to approximately 65–70. This improvement indicates the initial development of students' critical thinking skills, although some students were still in the fair category and had not yet achieved classical learning mastery.

In Cycle II, after improvements were made based on the reflection results, the average student score increased significantly to approximately 78–85. Most students reached the good category, and several students achieved the very good category. This improvement indicates that the use of IFP-based multimodal media had a more optimal positive effect on students' critical thinking skills.

Table 2: Students' Learning Mastery

Cycle	Number of Students	Students Achieving Mastery	Students Not Yet Achieving Mastery	Mastery Percentage
Cycle I	30	18	12	60,00%
Cycle II	30	26	4	86,67%

The analysis of learning mastery shows a significant improvement in each cycle. In the initial condition, the number of students achieving mastery was relatively low, amounting to less than half of the total number of students. In Cycle I, the number of students achieving mastery began to increase, although the classical mastery target had not yet been reached.

In Cycle II, student learning mastery increased significantly to more than 85%. This indicates that most students were able to achieve the established competency standards. Therefore, the success indicators of the study were achieved in Cycle II.

Table 3: Improvement in Average Class Scores

Aspect	Cycle I	Cycle II	Improvement
Mean Class Score	65,60	80,28	14,68
Highest Score	80,00	92,00	12,00
Lowest Score	50,00	68,00	18,00

Based on the observation results, student activity during the learning process increased considerably. In Cycle I, student activity was still in the fair category, with an average percentage of approximately 60–65%. Students tended to be passive, especially in asking questions and expressing opinions.

In Cycle II, student activity increased to the good category, with an average percentage of approximately 80–85%. Students became more active in asking questions, participating in discussions, and expressing ideas or opinions. Students' responses to the use of IFP media also showed a significant improvement, as they appeared more enthusiastic and engaged in the learning process.

Table 4: Results of Student Activity Observation

No	Observed Aspect	Cycle I (%)	Cycle II (%)	Category
1	Asking Questions Actively	58,00	82,00	Good
2	Participation in Discussions	62,00	85,00	Good
3	Ability to Express Opinions	60,00	83,00	Good
4	Problem-Solving Ability	64,00	86,00	Very Good
5	Response to IFP Media	70,00	90,00	Very Good
	Mean	62,80	85,20	Good

When reviewed based on the critical thinking indicators, all aspects improved from Cycle I to Cycle II. In Cycle I, the average score for each indicator was still in the range of 60–70, indicating that students' critical thinking skills were still in the developmental stage.

In Cycle II, all indicators improved, with average scores ranging from 75–85. The analysis and explanation indicators showed the most prominent improvement, indicating that students began to be able to break down problems and explain their reasoning logically and systematically. Meanwhile, the interpretation, evaluation, and inference indicators also showed significant improvement.

Table 5: Assessment Category Criteria

Score Range	Category
86–100	Very Good
71–85	Good
56–70	Fair
≤ 55	Poor

The research findings indicate that: students' critical thinking skills improved from the initial condition to Cycle II; student learning mastery increased significantly and achieved the classical target; student activity during the learning process improved from the fair category to the good category; and all critical thinking indicators improved, particularly in the aspects of analysis and explanation.

It can be concluded that the implementation of multimodal media based on Interactive Flat Panels (IFP) had a positive impact on improving students' critical thinking skills in mathematics learning.

Discussion

The findings of this study indicate that the use of multimodal media based on Interactive Flat Panels (IFP) consistently improved elementary school students' critical thinking skills. The improvement was evident not only in the average scores but also across all critical thinking indicators, reflecting a change in the quality of students' thinking processes rather than merely a quantitative increase in learning outcomes.

These findings confirm that the limitations of mathematics learning in elementary schools do not lie solely in the content or curriculum, but rather in how the content is represented to students. Conventional media, which are linear and one-way in nature, tend to restrict students' cognitive processes to the procedural level. In contrast, IFP-based multimodal media enable mathematical concepts to be presented through multiple representations simultaneously—visual, symbolic, and contextual—thereby enriching students' knowledge construction processes. The improvement in critical thinking skills observed in this study can be understood as a logical consequence of the enhanced quality of representation and learning interaction.

The most significant improvement in the analysis and explanation indicators suggests that students not only understood the information but also began to break down problems and communicate their reasoning logically. This indicates a shift from surface learning to deep learning, in which students no longer merely follow procedures but engage in reflective and evaluative thinking processes. These findings reinforce Facione's (2015) [3] framework, which states that critical thinking is an active process involving interpretation, analysis, evaluation, and integrated conclusion drawing.

The effectiveness of IFP-based multimodal media in this study cannot be separated from its interactive characteristics. Unlike passive digital media, IFPs enable direct interaction between students and the learning materials through touch, object manipulation, and real-time responses. This interactivity plays an important role in increasing cognitive engagement, which is a key prerequisite for the development of higher-order thinking skills. Therefore, the significant increase in student activity observed in Cycle II is not merely an indicator of participation, but rather an indicator of the improved quality of students' cognitive engagement.

The findings of this study are consistent with those of S. M. Alharbi *et al*. (2022) [2] and A. Ragab *et al*. (2024) [14], which showed that learning based on high-level cognitive activities contributes significantly to the development of HOTS. However, this study offers a more specific contribution by positioning multimodality as the core of the intervention rather than merely as a supplementary learning tool. Unlike previous studies that tended to focus on instructional models, this study demonstrates that media design—particularly the integration of multiple representational modes within a single interactive platform—plays an equally important role in shaping students' thinking processes.

The main novelty of this study lies in the integration of IFP-based multimodal media as a pedagogical strategy that directly targets the development of critical thinking skills in elementary mathematics learning. This study not only confirms the effectiveness of interactive media but also expands the understanding that the quality of learning is determined by the ability of media to provide learning

experiences that are rich in representation and interactivity.

The implications of these findings suggest the need for a paradigm shift in the development of mathematics learning in elementary schools, from a primary focus on teaching methods to the design of media-based learning experiences. Teachers are no longer merely presenters of content, but learning designers who are able to integrate various forms of representation to stimulate students' thinking processes. Without such changes, efforts to improve students' critical thinking skills may remain limited, even though the curriculum has emphasized HOTS.

Overall, the findings of this study confirm that the use of IFP-based multimodal media is not merely a technical innovation, but a pedagogical approach with a strong theoretical foundation and significant empirical impact on improving elementary school students' critical thinking skills.

Conclusion

This study demonstrates that the use of multimodal media based on Interactive Flat Panels (IFP) is effective in improving students' critical thinking skills in mathematics learning at the elementary school level. The improvements were evident not only in the average learning outcomes and students' mastery achievement, but also across all critical thinking indicators, reflecting enhancements in the quality of students' cognitive processes. The integration of multiple representations (visual, symbolic, and contextual) through multimodal media was proven to promote active engagement and strengthen students' analysis, evaluation, and explanation skills. Therefore, IFP-based multimodal media can be positioned as a relevant instructional strategy to support the development of higher-order thinking skills in the context of elementary education.

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How to Cite This Article

Ariyanto A, Utomo DP, Sugiarti. The use of multimodal media to improve critical thinking skills in mathematics learning for elementary school students. J Front Multidiscip Res. 2026;7(1):445–449. doi:10.54660/.JFMR.2026.7.1.445-449.

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