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From Surface Learning to Deep Understanding: Interactive Media as a Means of Strengthening Elementary Students' Critical Thinking

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Abstract

Digital transformation has created opportunities for integrating interactive media into learning processes. However, instructional practices in elementary schools remain largely surface-oriented and have not yet optimally fostered deep understanding or students' critical thinking skills. Empirical investigation is therefore required to explore the role of interactive media as a catalyst for the transition toward meaningful learning. This study aims to analyze the role of interactive media in strengthening elementary school students' critical thinking skills through deep learning processes. This quantitative study employed an explanatory survey design involving 680 elementary school teachers as respondents. Data were collected through a Likert-scale questionnaire measuring three reflective constructs: Interactive Media, Deep Learning, and Critical Thinking. Data analysis was conducted using SmartPLS 4. Partial Least Squares Structural Equation Modeling (PLS-SEM) was applied to examine both direct and indirect relationships among the variables. The findings show that the use of interactive media has a significant effect on deep learning. Deep learning was also found to have a significant effect on students' critical thinking skills with an f^2 value of 9,742. In addition, deep learning serves as a significant mediator in the relationship between interactive media use and students' critical thinking skills. These findings suggest that the effectiveness of interactive media in learning is not only determined by the intensity of its use, but by its capacity to facilitate reflective, analytical, and meaningful learning processes. The study concludes that integrating interactive media designed to support deep learning is an important strategy for strengthening critical thinking skills among elementary school students.

Keywords: Critical Thinking; Deep Learning; Interactive Media

1. Introduction

The rapid advancement of digital technology has driven significant changes in instructional practices in elementary education. Interactive media, such as instructional multimedia, digital applications, and technology-based platforms, are increasingly used to support teaching and learning processes (Ye et al., 2024). These media are perceived as capable of enhancing students' interest, visualizing abstract concepts, and facilitating more dynamic classroom interactions (M.-J. Yang & Zhu, 2024). In the context of elementary education, the

use of interactive media holds strategic potential because students are in the early stages of developing cognitive patterns and reasoning abilities (Mihailova, 2024). However, the utilization of interactive media in classroom practice remains largely focused on visually appealing content delivery, resulting in learning experiences that tend to be surface-oriented (Fazel & Sayaf, 2025).

A central challenge in contemporary learning lies in the suboptimal use of interactive media to promote deep conceptual understanding and the development of students' critical thinking skills (Lohr et al., 2024). In practice, learning activities often remain oriented toward surface learning (Harahap et al., 2024), characterized by an emphasis on information memorization, mechanical task completion, and limited student engagement in analysis, reflection, and meaning-making processes (Dang et al., 2024). Such learning patterns provide insufficient opportunities for students to connect concepts, evaluate information, and develop logical and critical reasoning skills.

This condition is particularly problematic because critical thinking skills cannot develop optimally without learning processes that foster high-level cognitive engagement (Gao & Huang, 2019). Deep understanding requires students not only to receive information passively but also to interpret meaning, connect new knowledge with prior experiences, and evaluate various sources of information (Nguyen et al., 2026). Consequently, instructional practices that focus solely on learning outcomes while neglecting students' cognitive processes may hinder the development of critical thinking abilities (Losada-Otalora et al., 2024).

This issue warrants closer examination given that elementary education represents a fundamental stage in the formation of higher-order thinking skills (Huang et al., 2024). At this stage, the learning patterns established will influence how students comprehend and process information in subsequent educational levels (Hawkins & Campbell, 2025). Therefore, strategic efforts are required to address this challenge through the integration of interactive media with instructional approaches that emphasize deep understanding (Cheng et al., 2025). Interactive media should be utilized not merely as tools for information delivery, but as pedagogical instruments capable of facilitating exploration, reflection, and active student engagement in the learning process (Zhu, 2025).

The rationale for conducting this study arises from the need to empirically understand how interactive media can function as a means of transitioning from surface learning to deep learning that supports the strengthening of elementary school students' critical thinking skills (Y. Yang, 2025). Although numerous studies have demonstrated that digital media can enhance motivation and learning engagement, empirical evidence regarding the pedagogical mechanisms linking interactive media to the development of critical thinking remains limited (J. Xu et al., 2025). This study is therefore essential to address questions

concerning the extent to which interactive media facilitate meaningful and reflective learning processes and how such processes influence students' critical thinking abilities (Chen, 2025).

This study contributes to addressing the research gap by integrating three key constructs interactive media, deep learning, and critical thinking skills within a comprehensive analytical framework (Ezeh et al., 2023). The research gap lies in the predominance of studies that examine the direct effects of interactive media on learning outcomes without considering the learning process as a critical variable (Cai et al., 2025). This study addresses that gap by positioning deep learning as the mechanism that mediates the relationship between the use of interactive media and students' critical thinking skills (Wang & Wang, 2023). Such an approach enables a more holistic understanding of the role of interactive media, not merely as technological tools, but as integral components of pedagogical design (Petro et al., 2025).

Research on interactive media has expanded rapidly alongside the increasing adoption of digital technologies in education (Y. Xu & Chen, 2025). Numerous studies have demonstrated that interactive media can enhance learning engagement, student motivation, and the effectiveness of instructional content delivery, particularly within technology-supported learning environments (Y. Xu & Chen, 2025). At the same time, contemporary educational research emphasizes the importance of deep learning as a pedagogical approach oriented toward conceptual understanding, knowledge integration (Ilmudinulloh et al., 2024; Vitasari & Sassi, 2024), and the development of higher-order thinking skills, including critical thinking and problem-solving (Zhuang et al., 2023). Nevertheless, studies that explicitly integrate the use of interactive media with deep learning approaches, particularly in the context of elementary education, remain relatively limited and underexplored empirically (Oliveira et al., 2025).

Based on this research gap, the innovation offered by this study lies in the development of an empirical model that comprehensively explains the role of interactive media as a pedagogical means of strengthening deep learning and critical thinking skills among elementary school students (Bickham et al., 2023). Unlike previous studies that primarily focus on the direct impact of digital media use on learning outcomes, this study emphasizes the learning process as a crucial mechanism mediating the influence of interactive media on the development of critical thinking skills (Feng et al., 2023). Moreover, this study adopts teachers' perspectives as key actors in the learning process, thereby providing a novel contribution by incorporating practitioners' viewpoints in evaluating the effectiveness of integrating interactive media and deep learning (Graham & Stough, 2025). Accordingly, this study is expected to offer both

theoretical and practical contributions to the development of innovative instructional strategies in elementary education (Tianyi, 2025).

The novelty of this study is reflected in its emphasis on the transition process from surface learning to deep understanding through the use of interactive media at the elementary school level (Gore, 2025). In contrast to prior research that predominantly focuses on educational technology features or examines the direct effects of interactive media on learning outcomes, this study positions the learning process as the key determinant of the effectiveness of interactive media integration (Guo et al., 2025). Thus, interactive media are viewed not merely as technological aids, but as pedagogical means capable of facilitating deeper cognitive engagement among students.

Furthermore, the novelty of this study is also evident in its examination of deep learning as a mediating variable in the relationship between interactive media and students' critical thinking skills. This approach remains relatively underexplored, particularly in the context of elementary education, which has traditionally emphasized lower-level cognitive outcomes. By integrating deep learning as an intervening variable, this study provides a more comprehensive understanding of the mechanisms through which interactive media contribute to the development of critical thinking skills. Therefore, this study is expected to offer theoretical contributions to the development of interactive media–based learning models, as well as practical implications for elementary school teachers in designing instruction that fosters conceptual understanding and higher-order thinking skills.

The authors expect that this study will provide both theoretical and practical implications for the development of interactive media–based learning in elementary education. The findings are anticipated to serve as a foundation for designing instructional approaches that are more strongly oriented toward deep understanding and the strengthening of students' critical thinking skills. For future researchers, this study opens opportunities for further investigations using more diverse methodological approaches, such as experimental or longitudinal studies, as well as the integration of student performance data to enhance the validity of the findings.

2. Method

2.1 Research Design

This study uses a quasi-experimental design to evaluate the effectiveness of digital interactive learning media based on a deep learning approach in improving students' critical thinking skills. This design was chosen because it provides ease in testing the difference between the experimental group using

interactive media and the control group using conventional learning methods, although without the strict randomization as done in pure experiments.

2.2 Population

In this study, the target population is all students at SDIT Masjid Raya Lantai Batu which is an educational institution chosen to implement digital interactive learning media based on a deep learning approach. This population was chosen because of their involvement in technology-based education as well as the challenges faced related to critical thinking skills that were the main focus of this study. The population of this study consists of students in grades IV A and IV B at SDIT Masjid Raya Lantai Batu who are considered to be able to interact with digital media and already have the basis of critical thinking skills that can be improved. In addition, data related to the experience of grade 4 teachers in applying IDeepLearn interactive learning media in private and public elementary schools in West Sumatra Province were also presented as follows.

Table 1. Distribution of Respondent

Teaching Experience	Number
< 5 years	170
5–10 years	180
11–20 years	190
> 20 years	140
Total	680

2.3 Data Collection Instruments

The data collection techniques used involve a variety of quantitative and qualitative methods to obtain a more comprehensive picture of media effectiveness, student engagement, and changes in their critical thinking skills. One of the techniques used is direct observation during the process of implementing learning media in the classroom. This observation aims to observe the level of student involvement, interaction between students and learning media, and how students solve problems presented in the media. These observations were made by researchers to ensure that students were using media to the fullest and to see how deep learning media affected students' critical thinking skills in real-life contexts in the classroom. Interviews with students and teachers were also used to explore their perceptions and experiences of the use of digital interactive learning media. These interviews provide more in-depth qualitative information about how students perceive their learning experiences and whether the media helps them think more critically. Interviews with teachers are also important to get their views on the ease of use of media, as well as its influence on the dynamics of learning in the classroom.

The instrument used in this study refers to Ennis' theory of critical thinking. This instrument will be validated by media experts, material experts

and learning experts to evaluate the extent to which the media meets the design criteria that are in accordance with the learning objectives, as well as the relationship between the media and the deep learning approach. This study employed a quantitative approach using a reflectively designed questionnaire instrument. The questionnaire consisted of positive statements comprising 18 indicators grouped into three main constructs:

Table 2. Instruments Interactive Learning Media (ILM)

Code	Statement
ILM1	The interactive media I use enable students to actively interact with the learning materials
ILM2	Interactive media facilitate concept exploration rather than mere information reception
ILM3	Interactive media help students connect learning materials with real-life situations
ILM4	Interactive media encourage students to ask questions during learning activities
ILM5	Interactive media make it easier for me to implement problem-based learning
ILM6	Interactive media increase students' cognitive engagement

Table 3. Instruments Deep Learning (DL)

Code	Statement
DL1	Learning activities encourage students to develop meaningful conceptual understanding
DL2	Students are given opportunities to analyze and interpret information
DL3	Students are required to explain the reasoning behind their answers
DL4	Learning requires students to connect prior knowledge with new knowledge
DL5	Learning activities challenge students to think beyond memorization
DL6	Reflection is used to deepen students' understanding

Table 4. Instruments Students' Critical Thinking (SCT)

Code	Statement
SCT1	Students are able to identify problems in learning situations
SCT2	Students are able to provide logical reasons for their opinions
SCT3	Students compare different alternative solutions
SCT4	Students evaluate information before accepting it as true
SCT5	Students are able to draw conclusions based on evidence
SCT6	Students demonstrate reflective attitudes toward their learning outcomes

Table 5. Product Validation Criteria

Decision Criteria	Interval Value	Description
Very Good	81 - 100	Very good values indicate outstanding performance.
Good	61 - 80	Good values indicate satisfactory and above-average performance.
Fairly Good	41 - 60	Fairly good values indicate areas that need improvement.
Poor	21 - 40	Poor values indicate significant deficiencies.
Very Poor	0 - 20	Very poor values indicate extremely poor performance.

2.4 Data Collection Procedures

Direct observation during the process of implementing learning media in the classroom, Interviews with students and teachers were also used to explore their perceptions and experiences of the use of digital interactive learning media, Questionnaires are also used to collect data from students regarding their experiences in using interactive learning media, including their involvement in learning, motivation, and their perception of critical thinking skills after using media, and Pre-test and post-test were used to measure changes in students' critical thinking skills before and after the use of interactive learning media.

2.5 Data Analysis

Quantitative data was analyzed using statistical tests, especially t-tests which aimed to compare the differences in pre-test and post-test results between the experimental group using interactive learning media and the control group using conventional learning. The T-test was used to determine whether there was a significant difference in critical thinking skills between the two groups after the application of interactive learning media. Qualitative data were analyzed using thematic analysis that aimed to identify key themes in the data obtained through interviews and questionnaires. Interviews with students and teachers were used to explore their perceptions of the use of interactive learning media and how they affect student engagement as well as changes in critical thinking skills.

3. Findings

The research findings indicate a significant increase in the mean scores of elementary school students' critical thinking skills in the experimental group that participated in learning activities supported by interactive media. This finding suggests that the use of interactive media is effective in encouraging students to transition from surface learning toward deeper levels of understanding. The frequency distribution of students' critical thinking skills showed that the majority of students were in the high (45%) and middle (55%) categories, after the application of interactive media by teachers in the learning process.

The results show that all the external loading values of the indicator exceed 0.70, ranging from 0.721 to 0.921. All indicators meet the criteria of convergent validity therefore can be considered valid to measure the research variables. These indicators are an appropriate and reliable measurement instrument to be used in this study. Discriminant validity testing using the cross-loading method shows that each indicator associated with interactive media has the highest cross-loading value on its corresponding construct compared to its cross-loadings on other constructs in the research model. In addition, all indicator cross-loading values are greater than 0.700. These results indicate that

each indicator strongly represents the construct it is intended to measure and does not more dominantly measure other constructs. Thus, it can be concluded that all indicators in the research model meet the criteria for discriminant validity and are declared valid based on cross-loading analysis.

Discriminant validity was further assessed using the Fornell–Larcker criterion, which shows that the square root of the Average Variance Extracted (AVE) for interactive media is greater than the correlations between that variable and other latent variables in the research model. The Fornell–Larcker analysis reveals that the square root of AVE values falls within a high range, with the lowest value at 0.894 and the highest at 0.962. These findings indicate that interactive media has a strong ability to explain the variance of its own indicators compared to its relationships with other constructs. Therefore, the research model satisfies the criteria for good discriminant validity based on the Fornell–Larcker approach, confirming that each construct possesses unique characteristics and can be clearly distinguished from other constructs in the model.

A variable is considered reliable when its Cronbach's alpha value exceeds 0.70, indicating a high level of internal consistency among indicators in measuring a latent construct in a stable and trustworthy manner. Based on the data presented in Table 5, the reliability test results show that all constructs in the research model meet the established reliability criteria. This is evidenced by composite reliability values ranging from 0.80 to 0.90 for each variable. These values indicate that the indicators forming each construct demonstrate a high level of reliability and are able to explain construct variance effectively. Thus, it can be concluded that all indicators in this study exhibit strong internal consistency in measuring their respective variables, and the research instrument is reliable and suitable for further analysis.

A construct is also considered reliable if it has an Average Variance Extracted (AVE) value of at least 0.50. Based on the data generated in the table above, all variables have AVE values exceeding 0.50, indicating that all constructs in this study meet the reliability criteria. AVE values above the minimum threshold indicate that each construct explains more than 50% of the variance of its indicators, suggesting good measurement quality. Moreover, when all indicators are standardized, the AVE value is equivalent to the average block communalities. This further confirms that each construct has adequate capacity to consistently and reliably represent its indicators.

The R-square (R^2) value for the latent variable Y is 0.931, indicating that 93.1% of the variance in deep learning can be explained by the independent variables included in the research model. This very high R-square value suggests that the structural model has exceptionally strong explanatory power, enabling it to account for most of the variation in deep learning. The remaining 6.9% of

variance is influenced by other factors outside the research model that were not examined in this study. Therefore, these results confirm that the research model demonstrates a strong capability to explain and predict deep learning.

The F-squared value (f^2) is used to determine the magnitude of the effect of interactive media on students' critical thinking skills within the structural model. The criteria for evaluating f^2 effect size are categorized as follows: $0.02 \leq f^2 < 0.15$ indicates a small effect, $0.15 \leq f^2 < 0.35$ indicates a medium effect, and $f^2 \geq 0.35$ indicates a large effect. Based on the research findings, variable X has an f^2 value of 9.742 on deep learning. This value far exceeds the threshold of 0.35, leading to the conclusion that interactive media exerts a very large and significant effect on deep learning. This finding demonstrates that interactive media plays a highly dominant role in explaining variation and improvement in deep learning within the context of this study.

Evaluation of the structural model in this study was conducted by assessing the significance of the relationships among variables using the bootstrapping procedure. Hypothesis testing was performed by examining the t-statistics and p-values generated through this process. A hypothesis is accepted when the results meet the established rule of thumb, namely a p-value less than 0.05 and a t-statistic greater than 1.96. In this study, a 5% significance level was applied using a one-tailed test approach; therefore, the critical t-value used as a reference was 1.96. Accordingly, bootstrapping results that meet these criteria indicate the presence of statistically significant effects among variables in the research model.

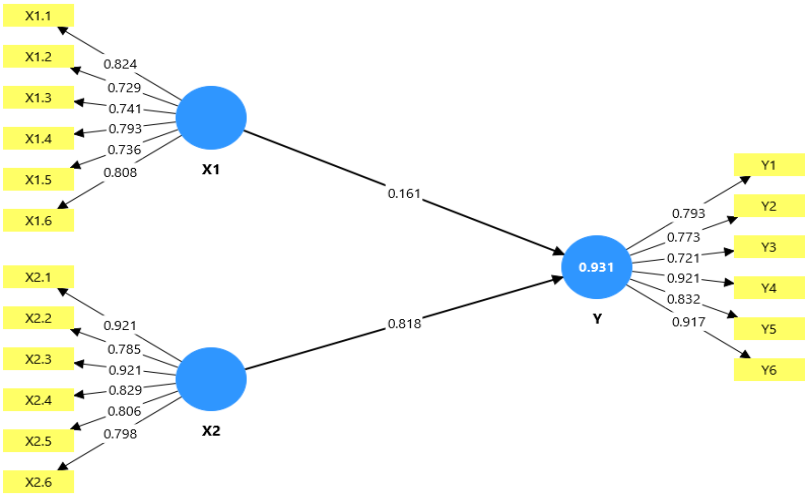

Figure 2. Diagram model Structural Equation Modeling–Partial Least Squares (SEM-PLS)

The analysis results indicate that all indicators of the Interactive Learning Media (X1) variable have loading values ranging from 0.729 to 0.824, the

Learning Strategy (X2) variable ranges from 0.785 to 0.921, and the Students' Critical Thinking (Y) variable ranges from 0.721 to 0.921. All outer loading values exceed the recommended threshold of 0.707, confirming that the research instrument demonstrates a high level of validity and reliability in measuring each construct. The path coefficient values of 0.161 for X1 and 0.818 for X2 indicate positive effects on Critical Thinking, with Learning Strategy (X2) acting as a particularly strong catalyst in linearly enhancing the quality of students' deep understanding. With an R-square value of 0.931, the model is able to simultaneously explain 93.1% of the variance in the Critical Thinking variable. This level of explanatory power categorizes the model as substantial and positions it as a key determinant in transforming surface learning patterns into deep understanding at the elementary school level.

These findings are consistent with previous studies demonstrating that the use of innovative learning media contributes positively to the development of students' higher-order thinking skills. However, this study provides additional contribution by emphasizing that the interaction of interactive media within deep learning processes functions as a critical factor in strengthening elementary school students' critical thinking skills. The data analysis shows that interactive media encourage students to actively engage in observing, analyzing, and reflecting on learning materials, thereby supporting their progression beyond surface learning toward deeper understanding. The distribution of critical thinking skill scores further reveals that the majority of students fall within the moderate to high categories, indicating the effectiveness of interactive media in continuously stimulating critical thinking processes within the context of elementary school learning.

4. Discussion

Learning in elementary schools plays a fundamental role in shaping students' thinking patterns, learning attitudes, and cognitive abilities. At this stage, instruction is not only oriented toward the acquisition of factual knowledge but also directed toward the development of higher-order thinking skills, particularly critical thinking (Suraj et al., 2025). However, instructional practices in elementary schools are still frequently dominated by surface learning approaches, which emphasize memorization, repetition of information, and the attainment of short-term outcomes. This condition results in students being insufficiently trained to analyze, evaluate, and reflect on information in a deeper manner (Daryanes et al., 2023). Therefore, instructional approaches are needed to shift learning from surface-level engagement toward deep understanding. Deep learning emphasizes students' active involvement in constructing knowledge through meaningful cognitive processes. In this approach, students are encouraged to develop holistic conceptual understanding, connect new knowledge with prior experiences, and apply their

understanding across different contexts (Saldanha et al., 2023). One of the primary indicators of deep learning is the development of students' critical thinking skills, such as the ability to ask questions, analyze information, draw conclusions, and solve problems logically. Achieving these objectives requires innovative and contextual instructional strategies, one of which is the utilization of interactive media (Rivas-Santisteban et al., 2023).

Interactive media refer to learning tools that enable active interaction between students and instructional content (Ilmudinulloh et al., 2024). Such media may include animations, simulations, interactive videos, educational games, and digital learning applications designed to stimulate student engagement (Ye et al., 2024). The use of interactive media in instruction provides more concrete and engaging learning experiences for elementary school students (Mihailova, 2024). Through visual, auditory, and interactive elements, students do not merely receive information passively but are directly involved in processes of exploration and concept discovery. The integration of interactive media within deep learning contexts holds substantial potential for strengthening elementary school students' critical thinking skills (M.-J. Yang & Zhu, 2024). Through interactive media, students can be presented with contextual problems that require observation, analysis, and decision-making (Lohr et al., 2024). For example, simulations or educational games may present specific scenarios that compel students to select strategies, predict outcomes, and evaluate the decisions they make. Such processes indirectly cultivate students' critical and analytical thinking skills from an early age (Dang et al., 2024).

Interactive media also support the development of students' reflective abilities. In learning environments supported by interactive media, students often receive immediate feedback on their actions or responses. This feedback encourages students to reflect on errors, understand the reasoning behind correct or incorrect answers, and refine their understanding (Fazel & Sayaf, 2025). Reflection is a crucial component of deep learning, as it shifts students' focus from merely achieving outcomes to examining the cognitive processes underlying their learning. The role of teachers in integrating interactive media is therefore critical. Teachers do not function solely as content deliverers but also as instructional designers who are able to employ interactive media pedagogically. Teachers must design learning activities that align with the goal of strengthening critical thinking, rather than using media merely as a form of entertainment (Gao & Huang, 2019). Accordingly, the selection of interactive media should take into account their suitability for elementary school students' characteristics, instructional objectives, and the complexity level of the subject matter.

In practice, teachers need to develop structured lesson plans that are oriented toward problem-solving. Interactive media should be used to facilitate activities that require students to think critically, engage in discussion, and draw conclusions. Teachers also need to guide students in formulating critical questions and provide opportunities for them to express their ideas. In this way, interactive media function as tools for deepening understanding rather than as simple visual aids. School support is also a key factor in the successful integration of interactive media into deep learning. Schools must provide adequate infrastructure, such as learning devices and appropriate access to digital media. In addition, enhancing teachers' competencies through training and mentoring is essential to enable them to utilize interactive media effectively. A school environment that supports instructional innovation will foster the development of more meaningful learning practices oriented toward the cultivation of critical thinking skills.

The use of interactive media in deep learning also contributes to increased learning motivation among elementary school students (Nguyen et al., 2026). Students' interest in visual displays and interactive activities makes them more enthusiastic about participating in learning. High levels of learning motivation encourage students to ask questions, experiment, and explore learning materials more actively. This condition strongly supports the creation of student-centered learning environments oriented toward deep understanding. Nevertheless, the integration of interactive media also presents several challenges (Losada-Otalora et al., 2024). Not all teachers possess adequate readiness or experience in using interactive media effectively. Moreover, there is a risk of excessive media use without appropriate pedagogical strategies, which may result in unfocused learning experiences (Huang et al., 2024). Therefore, careful planning and continuous evaluation are required to ensure that interactive media genuinely support the strengthening of students' critical thinking skills.

Overall, interactive media play a strategic role in facilitating the transition from surface learning to deep understanding among elementary school students. When supported by appropriate instructional design, interactive media can serve as effective tools for developing students' critical, analytical, and reflective thinking skills. The integration of interactive media not only enhances the quality of instructional processes but also helps equip students with the cognitive skills necessary to face learning challenges at subsequent educational levels. Accordingly, the use of interactive media in deep learning should continue to be developed as part of broader efforts to improve the quality of education in elementary schools.

5. Conclusion

The study concludes that the integration of interactive media in deep learning serves as an effective pedagogical strategy to facilitate the shift from

surface-level learning to deeper conceptual understanding, while improving the critical thinking skills of elementary school students. Deep learning supported by interactive media has a positive impact in reinforcing key dimensions of students' critical thinking, including the ability to ask relevant questions, identify relationships between concepts, analyze information, and evaluate the accuracy and relevance of learning materials. These findings offer practical implications for teachers in designing more student-centered instruction through the use of pedagogically directed and well-planned interactive media, as well as for schools in supporting the provision and utilization of relevant learning media.

Declaration of AI and AI-Assisted Technologies

During the preparation of this work the authors used DeepL (V.24.4.3) for optimizing language and readability. The authors have reviewed and edited the content as needed and take full responsibility for the content of the publication after the use of this tool/service.

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