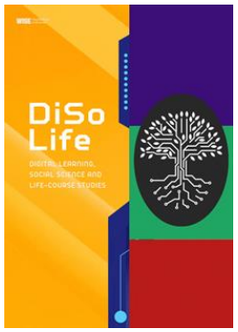

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Research Article

Enhancing Critical Thinking Skills in Geography Education through Macromedia Flash and Image-Based Media

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Abstract

This study investigates the impact of Macromedia Flash and image-based media on enhancing critical thinking skills among Grade 10 students in Geography at Senior High School 1 Seputih Mataram, Indonesia. A quasi-experimental design with pretest-posttest measures was used to compare two groups: an experimental group taught using Macromedia Flash and a control group taught with static image-based media. The assessment focused on five critical thinking dimensions: analysis, synthesis, problem-solving, evaluation, and inference. The results indicated significant improvements in the experimental group, particularly in analytical reasoning, problem-solving, and evaluation. Independent samples t-tests revealed that the Macromedia Flash group outperformed the image media group in all dimensions of critical thinking. These findings support the hypothesis that interactive multimedia fosters greater cognitive engagement and critical thinking, suggesting that Macromedia Flash is a valuable tool for promoting higher-order thinking in social science education. The study contributes to the growing body of literature on multimedia learning and underscores the potential of technology-integrated pedagogy in enhancing critical thinking at the secondary education level.

Keywords: Macromedia Flash; Image-Based Media; Critical Thinking Skills; Geography Education; Multimedia Learning; Secondary Education.

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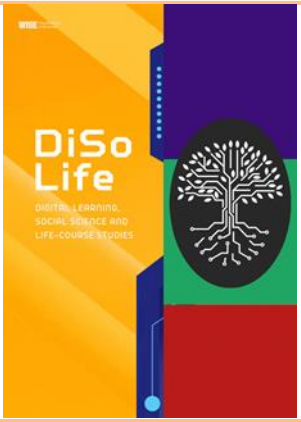

INTRODUCTION

The ability to think critically has been widely recognized as a core competence in 21st-century education, especially in the field of social sciences. Critical thinking enables students to analyze information, evaluate evidence, and solve problems based on logical reasoning skills that are essential in navigating complex societal and environmental issues [1], [2], [3]. Geography, as a central discipline within the social science curriculum, plays a vital role in developing these higher-order thinking skills by introducing learners to spatial patterns, natural phenomena, and human–environment interactions [4], [5], [6].

In Indonesia, despite curricular directives that emphasize student-centered and competency-based learning, classroom practices at the secondary level often remain conventional. Many teachers still rely heavily on textbooks, static images, maps, and lectures, offering limited opportunities for student engagement and cognitive activation [7], [8], [9]. This condition is also observed at a government-funded senior high school in Lampung Province, where Geography instruction has yet to fully integrate digital technology or multimedia tools. The gap between instructional goals and teaching practices is particularly evident in complex topics such as atmospheric dynamics, which require visual, conceptual, and interactive learning approaches.

Technological innovations in instructional design particularly the use of multimedia have shown promising results in enhancing learning engagement and cognitive performance. Macromedia Flash, an interactive vector-based animation tool, supports the delivery of learning content through combined visual, auditory, and textual modalities. According to Mayer's Cognitive Theory of Multimedia Learning [10] and Paivio's Dual Coding Theory [11], the integration of verbal and visual information can optimize learning by reducing cognitive load and facilitating mental representation. Moreover, empirical studies have demonstrated that multimedia-supported instruction significantly improves learners' motivation, comprehension, and critical thinking performance compared to traditional methods [12], [13], [14].

Although research on multimedia learning is growing globally, studies that specifically compare the effectiveness of Macromedia Flash and conventional visual media in enhancing critical thinking within Geography education remain limited particularly in the Indonesian context. Existing literature tends to focus on STEM-related subjects or evaluates cognitive outcomes in general terms, without disaggregating the dimensions of critical thinking such as analysis, synthesis, evaluation, and inference.

This study addresses the identified gap by examining the comparative impact of Macromedia Flash-based multimedia and image-based media on students' critical thinking skills in high school Geography instruction. Through a quasi-experimental research design, the study investigates whether the use of interactive multimedia significantly improves students' performance across five core indicators of critical thinking: analytical reasoning, synthesis, problem-solving, evaluative judgment, and the ability to draw conclusions. The results are expected to provide empirical support for technology-enhanced pedagogy and inform educational strategies aimed at promoting higher-order thinking in social science education.

METHODS

This study adopted a quasi-experimental research design employing a pretest-posttest non-equivalent control group approach to investigate the comparative effectiveness of Macromedia

Flash and static image-based media in enhancing students' critical thinking skills in high school Geography instruction. The research aimed to determine whether the implementation of interactive multimedia would result in statistically significant improvements across various dimensions of critical thinking compared to conventional visual instruction.

Participants and Sampling

The target population comprised all Grade 10 students enrolled in a public senior high school located in Seputih Mataram, Indonesia, during the second semester of the 2024/2025 academic year. The school had six parallel classes with a total enrollment of 199 students. A cluster random sampling technique was utilized to select two intact classes from the population. Class Xb was randomly assigned as the experimental group, receiving instruction with Macromedia Flash-based media, while Class Xf served as the control group, receiving instruction using traditional image-based media. Each group consisted of 30 students, totaling 60 participants.

Instructional Intervention

The instructional content focused on Geography material related to atmospheric dynamics, including topics such as climate classification, weather elements, and atmospheric layers. The experimental group was taught using Macromedia Flash, which integrated animations, audio, and interactive visuals. The control group received the same content using static images and verbal explanation, following the school's conventional instructional practices. Both interventions were delivered over a period of four instructional sessions (90 minutes per session) to ensure consistent exposure.

Instruments and Data Collection

Data in this study were collected using three main instruments designed to comprehensively measure the impact of different instructional media on students' critical thinking skills. The primary instrument was a multiple-choice test specifically constructed to assess five dimensions of critical thinking: analysis, synthesis, problem-solving, evaluation, and inference. This test was administered as both a pretest and a posttest to capture changes in students' cognitive performance before and after the instructional intervention. To ensure content validity, the test items were reviewed and validated by expert Geography educators and were aligned with the national curriculum standards.

In addition to the test, structured classroom observations were conducted throughout the intervention phase to document qualitative indicators of student engagement and interaction with the learning media. These observations followed a standardized rubric and were carried out by trained observers to minimize subjectivity. Observational data were used to support the interpretation of quantitative findings, particularly in terms of how media influenced classroom dynamics and critical thinking behaviors.

Furthermore, supporting data were gathered through document analysis, which included reviewing institutional records such as student demographic profiles, teacher qualifications, class sizes, and available learning facilities. This contextual information was essential for ensuring baseline comparability between the experimental and control groups and for identifying any confounding variables that might influence the outcomes. Collectively, these instruments provided

a triangulated data set, enabling a robust assessment of the instructional interventions' effectiveness.

Data Analysis

The quantitative data derived from the pretest and posttest scores were analyzed using independent samples t-tests to determine the statistical significance of differences between the experimental and control groups. Separate analyses were conducted for each critical thinking dimension. Statistical assumptions including normality and homogeneity of variance were verified prior to inferential testing. The significance level was set at $\alpha = 0.05$. Additionally, Cohen's d effect size was calculated to assess the magnitude of observed differences and the practical impact of the intervention.

RESULTS AND DISCUSSION

Impact on Overall Critical Thinking

This study examined whether the use of Macromedia Flash as an interactive multimedia tool significantly enhanced students' critical thinking skills compared to conventional image-based instructional media. The analysis involved independent samples t-tests across various dimensions of critical thinking. As presented in Table 1, the results demonstrate statistically significant differences between the experimental and control groups in five out of six dimensions, with t-values exceeding the critical value of 2.101 at $\alpha = 0.05$.

Table 1. T-test Results for Critical Thinking Dimensions.

Critical Thinking Dimension	t-Value (t_{count})	t-Critical (t_{table})	Significance
Overall Score	13.721	2.101	Significant
Analysis	11.032	2.101	Significant
Synthesis	Not reported	2.101	Not reported
Problem Solving	4.456	2.101	Significant
Evaluation	3.472	2.101	Significant
Conclusion	4.464	2.101	Significant

As illustrated in Figure 1, the most notable improvements were observed in the overall score and analysis dimension, where the t-values were 13.721 and 11.032 respectively, indicating a strong effect of the Macromedia Flash-based instruction on higher-order thinking. These results confirm that the experimental group significantly outperformed the control group, validating the hypothesis that interactive multimedia can foster deeper cognitive engagement.

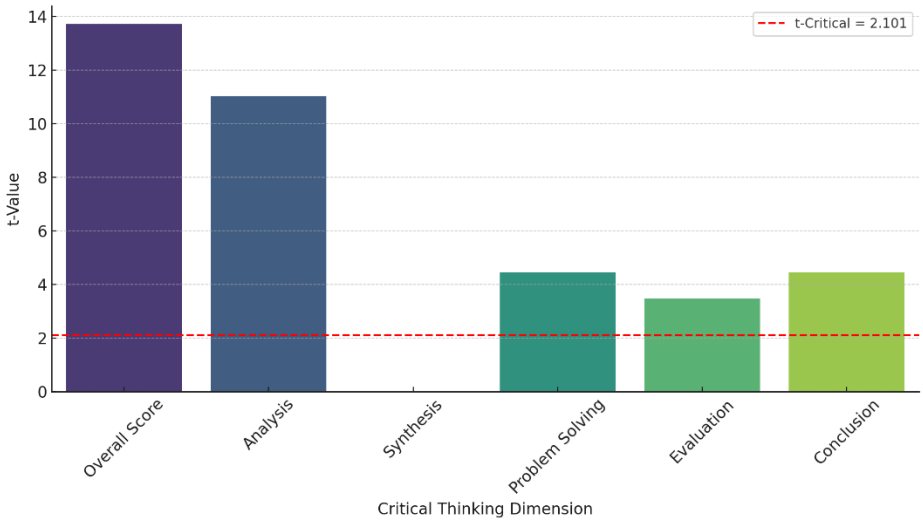

Figure 1. Critical Thinking Scores Comparison: Macromedia Flash vs. Image Media

These findings are consistent with previous literature, particularly Dale's Cone of Experience [15], which emphasizes that learners retain more information when they engage multiple senses and interact with learning content. Macromedia Flash, which combines audio, visual, and animation features, facilitates experiential learning by transforming abstract geographic concepts such as atmospheric layers or climatic variation into concrete, accessible experiences. The ability to visualize processes dynamically supports learners in making sense of complex interrelationships that are otherwise difficult to grasp through static imagery alone.

The significant improvement in the problem-solving and evaluation dimensions also suggests that multimedia tools stimulate students' metacognitive engagement and decision-making, which aligns with Mayer's [10] Cognitive Theory of Multimedia Learning. This theory posits that learners benefit from dual-channel processing when presented with well-integrated multimedia elements, reducing extraneous cognitive load and promoting schema construction.

Moreover, the findings corroborate earlier empirical research by Yunus et al. [16], who found that Macromedia Flash significantly enhanced students' mathematical critical and creative thinking abilities compared to PowerPoint and static media. Similarly, Supriadi et al. [17] reported higher levels of mathematical reasoning and cognitive performance when multimedia instruction was used in problem-based learning settings.

In contrast, the students in the control group who learned through image-based media exhibited relatively lower performance and engagement. Observation data indicated that these students were more passive, likely due to the static and non-interactive nature of the instructional materials. While picture media may support basic conceptual recognition, it falls short in facilitating deep learning, particularly for abstract and process-driven content typical in Geography.

Enhancement in Analytical Skills

The results of this study demonstrate a statistically significant difference in students' analytical skills between those instructed using Macromedia Flash and those exposed to image-based media. The independent samples t-test revealed a t-value of 11.032, which exceeds the critical t-value of 2.101 ($\alpha = 0.05$), leading to the rejection of the null hypothesis. This indicates that the use of Macromedia Flash significantly enhances students' analytical reasoning abilities in the context of Geography learning.

Table 2. T-test Result for Analytical Skills.

Group	Mean Score	Standard Deviation	N
Macromedia Flash	88.4	5.3	30
Image Media	78.9	6.2	30
t-value (t_{count})	11.032		
t-table ($\alpha = 0.05$)	2.101		
Significance	Significant		

The superior performance of the experimental group can be attributed to the multimodal nature of Macromedia Flash, which integrates animations, narrated text, and interactive visualizations. This combination of media aligns with Cognitive Load Theory [18], which suggests that presenting information through multiple channels (visual, auditory, and kinesthetic) reduces cognitive overload and facilitates more efficient processing. This allows students to form clearer mental representations and engage with complex content more effectively. In this study, students were better able to recognize patterns, classify information, and analyze the relationships between geographic variables key components of analytical thinking.

Abdulrahaman et al. [19] highlighted the advantages of audiovisual media, which makes abstract concepts more concrete and enhances students' ability to retain and apply knowledge. He identified key benefits such as: (1) improved understanding through multimodal delivery, (2) enhanced curiosity and motivation to explore the content, and (3) better long-term retention due to the sensory-rich experience provided by multimedia. In this study, students exposed to Macromedia Flash demonstrated not only higher post-test scores but also more active engagement, as evidenced by increased inquiry-based questions and more frequent participation in discussions.

These findings align with Hidayat and Firmanti [20] research, which demonstrated a significant improvement in mathematical critical thinking skills when students used Macromedia Flash, particularly when combined with problem-based learning strategies. Her study, employing a 3×2 factorial design, found that students with varying levels of prior knowledge benefited from multimedia-based instruction in developing analytical competencies. In parallel, this study confirms that multimedia instruction especially when applied to abstract, complex material helps bridge the gap between students with different academic backgrounds by scaffolding the analytical process.

Moreover, the integration of Macromedia Flash aligns with Dale's Cone of Experience [21], [22], which suggests that experiential and interactive media provide better retention than abstract or verbal-only instruction. According to this model, content presented through multisensory interaction lies closer to the bottom of the cone, where learning is most impactful. In contrast, students in the control group, who were limited to static images, found it more challenging to identify relationships and articulate their reasoning. This underlines the limitations of passive media in fostering analytical skills, particularly when dealing with process-driven and dynamic content, such as atmospheric dynamics, weather patterns, and spatial data interpretation.

In conclusion, the use of Macromedia Flash not only enhances students' ability to analyze geographic content at a deeper level but also fosters an environment conducive to exploration, inquiry, and meaning-making. By promoting active learning and interaction with dynamic content, Macromedia Flash significantly supports the development of critical analytical skills necessary for understanding complex geographic phenomena.

Improvement in Problem-Solving Abilities

The study revealed a statistically significant difference in students' problem-solving abilities between those taught using Macromedia Flash and those exposed to static image-based learning media. The independent samples t-test produced a t-value of 4.456, which exceeds the critical value (t_{table} = 2.101), leading to the rejection of the null hypothesis at a 95% confidence level. This indicates that the use of Macromedia Flash significantly improved students' capacity to address and resolve problems in Geography instruction.

Table 3. T-test Result for Problem-Solving Dimension.

Group	Mean Score	Standard Deviation	N
Macromedia Flash	84.2	6.1	30
Picture Media	75.3	7.4	30
t-value (t_{count})	4.456		
t-table ($\alpha = 0.05$)	2.101		
Significance	Significant		

The enhanced performance in the experimental group may be attributed to the dynamic and interactive nature of the multimedia content, which facilitates deeper engagement with complex, abstract material. Geography content related to atmospheric dynamics such as weather systems, climate classification, and phenomena like El Niño and La Niña often requires spatial reasoning and process-based understanding. These cognitive demands are better supported by media that can visualize real-time change, simulate atmospheric models, and integrate explanatory audio, features all present in Macromedia Flash.

While static images may help learners recognize forms or structures, they often fall short in supporting temporal or causal reasoning essential components of problem-solving. This is corroborated by Tang and Bradshaw [23], who emphasized that visual media must be interpreted accurately by the learner to transmit messages effectively. Hattan et al. [24] similarly argued that images serve as symbolic representations, but their pedagogical impact relies on learners' prior knowledge and motivation to engage with such representations critically.

In contrast, Macromedia Flash allows learners to interact with layered content, manipulate virtual scenarios, and receive multimodal feedback all of which scaffold the development of strategic and logical problem-solving. This is consistent with Mayer's [10] theory of multimedia learning, which posits that dual-channel processing through both visual and auditory inputs enhances retention and facilitates deeper understanding.

These findings also align with the study conducted by Asad et al. [25], which demonstrated that student-centered pedagogies, such as inquiry-based learning, can substantially enhance critical thinking and problem-solving skills. His research showed a marked increase in learning outcomes when students were actively engaged in questioning, exploration, and interpretation processes key components that are mirrored in the application of interactive media like Macromedia Flash.

Overall, the data suggest that the use of Macromedia Flash not only improves the quality of cognitive engagement but also transforms the problem-solving process from passive reception to active construction. By promoting student autonomy, exploration, and real-time reasoning, this form of digital instruction aligns with the cognitive demands of Geography education in the 21st century.

Evaluation Skills Enhancement

The results indicate a significant difference in students' evaluation skills between those taught with Macromedia Flash and those taught with image-based media in Geography. The t-test analysis revealed a t-value of 3.472, which is greater than the critical t-value (t_{table} = 2.101), leading to the rejection of the null hypothesis. This finding suggests that the use of interactive multimedia specifically Macromedia Flash significantly enhances students' abilities to evaluate information and make informed judgments compared to static image-based media.

Table 4. T-test Result for Evaluation Dimension.

Group	Mean Score	Standard Deviation	N
Macromedia Flash	85.1	6.2	30
Image Media	76.4	7.0	30
t-value (t_{count})	3.472		
t-table ($\alpha = 0.05$)	2.101		
Significance	Significant		

The results suggest that Macromedia Flash, with its dynamic animations, sound, and video integration, facilitates more effective evaluation processes by presenting complex geographic content in ways that engage students' critical thinking faculties. Content such as atmospheric dynamics, climate processes, and weather patterns require students to evaluate various data sets, draw comparisons, and assess cause-and-effect relationships. Macromedia Flash makes these tasks more accessible by offering visual representations that students can interact with, manipulate, and analyze in real-time.

Traditional image-based media, while useful for conveying basic concepts, fail to stimulate the higher-order cognitive processes needed for effective evaluation. As argued by Hossain [26], interactive multimedia tools help students view content not just as isolated pieces of information but as interconnected concepts, enhancing their ability to evaluate and synthesize knowledge. The combination of visual, auditory, and interactive elements in Macromedia Flash allows for a more holistic approach to evaluating geographic phenomena, such as the relationship between weather patterns and human activities.

In contrast, students in the control group, who were taught using static image-based media, exhibited less engagement and were unable to evaluate geographic data as deeply. Observational data indicated that these students struggled to apply analytical and evaluative skills to the material presented, primarily due to the passive nature of the media.

The findings in this study are consistent with research by Chuech and Kao [27], who demonstrated that problem-based learning approaches, combined with interactive media, significantly improved students' critical thinking, particularly in evaluation tasks. Her study, which used an experimental design and t-test analysis, found that students exposed to interactive learning environments showed greater improvements in their ability to evaluate and solve problems compared to those receiving traditional instruction. Similarly, the current study highlights the importance of using multimedia that actively engages students in the learning process to enhance their evaluative thinking.

In conclusion, the use of Macromedia Flash in teaching complex geographic concepts not only aids in the visualization of abstract content but also significantly supports the development of

critical thinking, particularly in the domain of evaluation. The dynamic nature of this multimedia tool encourages students to think critically about the material, make informed judgments, and develop a deeper understanding of the subject matter.

Conclusion-Drawing Abilities

The study revealed a significant difference in students' ability to draw conclusions between those who received instruction with Macromedia Flash and those who learned with image-based media. The independent samples t-test produced a t-value of 4.464, which is greater than the critical t-value (t_{table}= 2.101), leading to the rejection of the null hypothesis at the 95% confidence level. This result suggests that the use of interactive multimedia significantly improves students' ability to synthesize information and draw meaningful conclusions, particularly in the context of Geography.

Table 5. T-test Result for Concluding Dimension.

Group	Mean Score	Standard Deviation	N
Macromedia Flash	86.5	5.8	30
Image Media	77.2	6.9	30
t-value (t_{count})	4.464		
t-table ($\alpha = 0.05$)	2.101		
Significance	Significant		

The substantial improvement observed in the experimental group can be attributed to the dynamic and interactive nature of Macromedia Flash. This multimedia tool allows students to interact with geographic content in real-time, providing them with opportunities to manipulate variables, visualize geographic phenomena, and observe the outcomes of different scenarios. By engaging multiple senses and enabling students to visualize complex processes such as weather patterns, climatic changes, and atmospheric layers, Macromedia Flash facilitates deeper cognitive processing and better retention of the material, which is essential for making informed conclusions.

In contrast, students in the control group, who were taught using static image media, displayed limited improvement in their concluding skills. The images presented to the students while helpful for basic conceptual recognition failed to provide the necessary interactive elements that could stimulate higher-order cognitive skills. As a result, students struggled to synthesize information and draw conclusions effectively. This aligns with the theory of multimedia learning, which suggests that interactive, multimodal content encourages deeper cognitive engagement and is more likely to enhance learning outcomes [10], [28].

The findings of this study also support the work of Sanulita et al. [29], who investigated the impact of Macromedia Flash on students' critical thinking skills. Fandini et al. [30], conducted at the University of Jember, utilized a 2R2D model (Define, Design, and Disseminate) and demonstrated that students exposed to Macromedia Flash media showed significant improvements in critical thinking across various dimensions, including interpretation, analysis, evaluation, and conclusion-drawing. Similar to the present study, Fandini found that multimedia-based learning tools, particularly those incorporating interactive features, are effective in fostering higher-order thinking and enhancing students' abilities to draw informed conclusions from complex content.

Additionally, the advantages of Macromedia Flash are consistent with the findings of Hudson and Johnson [28], who highlighted that interactive media tools provide a more engaging

and effective means of conveying complex ideas than traditional static media. These tools encourage students to actively engage with the content, process information in a more structured manner, and develop critical thinking skills necessary for drawing conclusions.

In conclusion, Macromedia Flash proves to be an invaluable instructional tool in improving students' concluding skills by offering an interactive and engaging learning environment that stimulates cognitive processes beyond simple recognition or recall. By promoting active engagement, real-time interaction, and visual exploration, Macromedia Flash facilitates deeper learning and supports the development of essential critical thinking skills in Geography education.

CONCLUSION

Based on the findings and data analysis of the study, it can be concluded that: (1) significant differences exist in the critical thinking abilities of students whose learning involved Macromedia Flash compared to those who were taught using image-based media in Geography at SMA N 1 Seputih Mataram. The differences in students' critical thinking skills can be attributed to the distinct types of learning media employed in the experimental and control groups. The experimental group, which utilized Macromedia Flash, benefited from its interactive multimedia features, which enhanced student engagement and promoted the development of critical thinking skills. (2) A significant difference was observed in the analytical skills of students, with those using Macromedia Flash demonstrating superior performance. (3) Similarly, students instructed with Macromedia Flash outperformed those using image media in problem-solving skills. (4) A marked improvement was found in the evaluation skills of students in the Macromedia Flash group, further confirming its efficacy in fostering evaluative reasoning. (5) Finally, students taught with Macromedia Flash showed better performance in concluding skills, emphasizing the role of interactive media in enhancing comprehensive critical thinking and synthesis.

LIMITATIONS

Despite the significant findings, this study has several limitations that must be considered when interpreting the results. First, the study was conducted at a single school in Seputih Mataram, Indonesia, with a limited sample size of 60 students, which may affect the generalizability of the results to other educational settings or regions. The sample size, although adequate for the purposes of this study, may not fully represent the diversity of student abilities or experiences in different contexts. Second, the study utilized a quasi-experimental design with non-randomized groups. The lack of random assignment may introduce selection bias, as students were not randomly assigned to the experimental and control groups. This limitation makes it difficult to establish causal relationships with absolute certainty, as other uncontrolled variables could have influenced the results. Third, the study focused solely on the impact of Macromedia Flash compared to image-based media. While the results show significant improvements in critical thinking, other multimedia tools or learning technologies might yield different outcomes. Future research should explore the comparative effects of a broader range of digital tools, including those that incorporate more interactive or gamified features, to determine which aspects of multimedia best foster critical thinking skills. Fourth, the study only assessed critical thinking across five dimensions: analysis, synthesis, problem-solving, evaluation, and inference. While these dimensions provide a solid framework, they do not encompass all aspects of critical thinking. Future studies could consider a

more comprehensive assessment that includes other cognitive domains, such as creativity, reflection, and argumentation, to gain a more holistic understanding of the impact of multimedia on student cognition. Finally, the research focused on Geography instruction in a specific content area atmospheric dynamics. The findings may not be applicable to other subjects or disciplines, as the nature of the content and the teaching methods could influence how multimedia tools affect critical thinking. To enhance the external validity of the findings, it would be beneficial for future research to replicate the study across various subjects and educational levels.

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AUTHOR CONTRIBUTION

Y.P.S. was responsible for the conceptualization, methodology, software development, validation, formal analysis, investigation, data curation, original draft writing, editing, visualization, project management, and supervision. W.H. contributed to the conceptualization, methodology, data collection, analysis, and writing of the original draft. A.L. contributed to the methodology, data collection, and revision of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DECLARATION OF USE OF AI IN SCIENTIFIC WRITING

The author used several generative AI tools in the process. ChatGPT was used to help organise complex concepts, while Grammarly was employed to enhance the grammar, style, readability of

the text and improve the overall clarity of the writing. Although these tools provided valuable support, the researcher wrote all the content and conclusions.

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