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The Role of Interactive Learning Media in Deep Learning: A Study on Critical Thinking Skills in Elementary Schools

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ABSTRACT

Background: The development of twenty-first-century education requires students to possess higher-order thinking skills, particularly critical thinking, which enables them to analyze information, evaluate perspectives, and make reasoned decisions. In elementary education, the integration of interactive learning media and deep learning approaches is increasingly considered important to support meaningful learning and foster students' cognitive development.

Purpose: This study aims to analyze the role of interactive learning media in facilitating deep learning to support the development of critical thinking skills among elementary school students.

Method: The study employed a mixed-method approach using a sequential explanatory design. Quantitative data were collected through a teacher perception questionnaire and analyzed using Partial Least Squares–Structural Equation Modeling (PLS-SEM) with the assistance of SmartPLS software. Qualitative data were subsequently used to elaborate and interpret the quantitative findings.

Results: The findings indicate that interactive learning media and deep learning have not yet demonstrated a strong direct effect on students' critical thinking skills. However, both elements function as facilitators within the learning process. The development of critical thinking skills requires the consistent integration of analytical and reflective learning activities within classroom instruction.

Conclusion: Interactive learning media and deep learning should be positioned as supporting components within the broader learning ecosystem rather than as standalone determinants of critical thinking development. Their effectiveness largely depends on how teachers integrate these elements with pedagogical strategies that encourage sustained student engagement, reflection, and meaningful learning experiences.

KEYWORDS

Critical Thinking, Deep Learning, Interactive Learning Media

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INTRODUCTION

The development of education in the twenty-first century requires students to possess various higher-order thinking skills, one of which is critical thinking. Critical thinking skills serve as an essential foundation for students in navigating the complexity of information,

rapid technological advancements, and increasingly dynamic social changes (Manurung et al., 2023). This ability enables students to analyze information objectively, evaluate multiple perspectives, and make rational decisions (Panca & Parisu, 2025). At the elementary school level, the development of critical thinking needs to be fostered from an early stage as a foundation for successful learning in subsequent educational levels (Irawan et al., 2025). The learning process in elementary schools plays a strategic role in shaping students' patterns of thinking, attitudes, and character (Syafitri et al., 2021). Learning that is systematically and reflectively designed can help students optimally develop their critical thinking potential.

The use of digital technology in education continues to increase alongside ongoing technological developments (Xu, J., Akhter, S., & Apuke, O. D.,2025). Interactive learning media has become one of the innovations widely utilized in the learning process at the elementary school level (Putri et al., 2025). This type of media enables two-way interaction between students and learning materials through visual displays, audio elements, and technology-based activities. Such interaction can enhance students' interest in learning, motivation, and engagement in the learning process (Maghfiroh et al., 2024). Interactive learning media also provides students with opportunities to learn independently and exploratively according to their individual abilities. Various studies indicate that the use of interactive media can support a deeper understanding of concepts (Fitriani, A., Santiani, 2025). However, the implementation of interactive learning media is not always accompanied by pedagogical planning oriented toward the development of critical thinking.

The deep learning approach has become one of the main focuses in efforts to improve the quality of education (Ali et al., 2025). Deep learning emphasizes comprehensive conceptual understanding, connections between knowledge, and students' reflective abilities (Azka, 2024). This approach encourages students not merely to memorize information but to connect knowledge with real-life experiences (Widjayanti et al., 2019). Deep learning also requires students to conduct analysis, evaluation, and synthesis of the materials being studied. The implementation of this approach requires careful instructional planning as well as adequate pedagogical competence from teachers (Kartini et al., 2020). The reality in the field indicates that the application of deep learning in elementary schools still faces various challenges, particularly related to instructional design and educators' readiness.

Interactive learning media and deep learning have considerable potential to support the creation of meaningful learning experiences (Sodikin et al., 2025). This potential can be observed through increased student participation, improved quality of learning interactions, and deeper understanding of learning materials (Assidiqi et al., 2026). The quality of learning is determined not only by the use of particular media or approaches but also by the pedagogical strategies implemented by teachers (Handayani et al., 2024). The development of critical thinking skills is influenced by various factors, including the learning environment, student characteristics (Afifah et al., 2022), and institutional support. Integration among learning media, instructional approaches, and learning objectives becomes a crucial aspect in achieving optimal outcomes (Cahyaningtias & Ridwan, 2020). Learning that focuses solely on the use of technology without careful planning tends to be less effective (Azizatunnisa et al., 2022). This condition indicates that the development of critical thinking requires a holistic and sustainable approach.

A review of previous studies indicates that research examining the relationship between interactive learning media, deep learning, and critical thinking skills remains relatively limited (Yani et al., 2025), particularly at the elementary school level (Fitriani, A., Santiani, 2025). Most studies tend to emphasize either the use of learning media or instructional methods separately (Anwar, Moh, Sodik, 2025). This fragmented research focus has resulted in a less comprehensive understanding of the learning process (Isnayanti, A., N., et.al., 2025). Variations in educational contexts and student characteristics also influence the research outcomes obtained (Panggabean & Misykah, 2025). These limitations indicate the existence of a research gap that requires further investigation (Sari, 2025). Studies that integrate multiple learning variables simultaneously are still needed in order to obtain a more comprehensive understanding.

This study aims to analyze the role of interactive learning media in facilitating deep learning to enhance the critical thinking skills of elementary school students. The focus of this research is directed toward understanding the relationship between the use of learning media, instructional approaches, and the development of students' thinking abilities (Azizatunnisa et al., 2022). The findings of this study are expected to contribute to the development of learning theories at the elementary education level (Yani et al., 2025). The results are also expected to serve as a reference for teachers in designing more meaningful learning experiences (Afifah et al., 2022). In addition, this research may provide considerations for policymakers in developing educational programs. Therefore, this study is expected to support the continuous improvement of learning quality in elementary schools.

RESEARCH METHODOLOGY

Research Design

This study employed a mixed-method approach using a sequential explanatory design, which combines quantitative and qualitative methods in a sequential manner. This approach was selected to obtain a comprehensive understanding of the role of interactive learning media and deep learning in facilitating the critical thinking skills of elementary school students (Akyuna et al., 2026). The first stage of the study involved collecting and analyzing quantitative data to examine the relationships among the research variables. The second stage was followed by qualitative data collection to deepen and explain the quantitative findings obtained (Mixed & Lumajang, 2024). The use of this design enables researchers not only to identify patterns of relationships among variables but also to understand the learning context and processes underlying those results.

Research Context and Participants

This research was conducted at the elementary school level where interactive learning media had been implemented in the learning process. The research participants consisted of elementary school teachers who were directly involved in the planning, implementation, and evaluation of learning activities using interactive media (Marcos et al., 2025). Teachers were selected as the primary respondents because they possess comprehensive experience and perspectives regarding classroom learning practices and students' learning behaviors. Participants were selected using a purposive sampling technique, with criteria including teachers who actively use interactive learning media and implement learning oriented toward conceptual understanding. The number of participants was determined based on the requirements for quantitative analysis using PLS-SEM and the need for in-depth qualitative data.

Research Instruments

The research instruments were developed based on theoretical studies and previous research relevant to the study variables. The quantitative instrument consisted of a closed-ended questionnaire used to measure three main constructs: Interactive Learning Media (Isnayanti, A., N., et.al., 2025), Deep Learning Instruction, and Students' Critical Thinking Skills, based on teachers' perceptions. All instrument indicators were formulated as statements using a Likert scale. The instrument development process involved adapting established conceptual frameworks and modifying them to suit the context of elementary school learning and thematic instruction.

Table 1. Dimensions & Indicators Interactive Learning Media

Code	Statement
MPI1	The learning media I use enables students to interact actively, rather than merely watching or listening.
MPI2	The media provides immediate feedback on students' responses.
MPI3	The media allows independent exploration (e.g., selecting menus, learning paths, or simulations).
MPI4	The media helps students understand abstract concepts through visualization or simulation.
MPI5	The media encourages cognitive engagement rather than merely visual interest.

Table 2. Dimensions & Indicators Construct 2: Deep Learning Instruction

Code	Statement
DLI1	The learning activities I design require students to understand the reasoning behind answers, not merely the correct answer.
DLI2	Students are asked to relate the material to real-life situations or daily experiences.
DLI3	The learning process provides opportunities for reflection on learning outcomes.
DLI4	Students are trained to explain their understanding using their own words.
DLI5	Interactive media helps make learning more meaningful and deeper.

Table 3. Dimensions & Indicators (Teachers' Perceptions of Student Behavior)

Code	Statement
KBK1	Students are able to ask relevant and in-depth questions.
KBK2	Students are able to provide reasons for their answers or opinions.
KBK3	Students can compare several alternative solutions.
KBK4	Students are able to draw conclusions based on available information.
KBK5	Interactive media helps students think more critically during learning.

Data Analysis

The questionnaire instrument in this study was developed based on indicators representing the constructs of Interactive Learning Media (MPI), Deep Learning Instruction (DLI), and Students' Critical Thinking Skills (KBK). All indicators were developed through adaptation and modification of relevant theoretical frameworks and adjusted to the context of elementary school learning. This study employed a five-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, and 5 = Strongly Agree. This scale was used to measure respondents' level of agreement with each statement in the questionnaire.

Quantitative data were analyzed using the Partial Least Squares–Structural Equation Modeling (PLS-SEM) approach with the assistance of SmartPLS software. The analysis involved evaluating the measurement model (outer model) to assess construct validity and reliability, as well as evaluating the structural model (inner model) to examine the relationships among the constructs MPI, DLI, and KBK. In addition to structural analysis, the data were also analyzed descriptively to illustrate teachers' response tendencies toward each research construct. The categorization of assessment results was determined based on the mean scores of respondents, which were classified into specific scoring intervals. The quantitative findings were further enriched with qualitative data obtained through interviews, which were analyzed thematically to strengthen and explain the research findings. The Likert scale categories used in this study are presented as follows:

Table 4. Average Score Assessment of Variables

Response	Condition Indication	Score Range	Score
Strongly Agree	Very Good	4.21 – 5.00	5
Agree	Good	3.41 – 4.20	4
Neutral	Neutral / Fair	2.61 – 3.40	3
Disagree	Poor	1.81 – 2.60	2
Strongly Disagree	Very Poor	1.00 – 1.80	1

RESULT AND DISCUSSION

Descriptive data indicate an increase in the mean scores of students' critical thinking skills among the group participating in learning integrated with interactive learning media. The frequency distribution shows that 45% of students fall into the high category and 55% into the moderate category. These findings suggest that the implementation of interactive learning media can positively support the development of students' critical thinking skills. The results of the measurement model testing show that all indicators have outer loading values above 0.70, ranging from 0.738 to 0.903.

These results confirm that all indicators meet the criteria for convergent validity. Therefore, the indicators are considered valid in measuring the constructs of Interactive Learning Media, Deep Learning Instruction, and Critical Thinking Skills.

Discriminant validity testing through cross-loading analysis shows that each indicator has the highest loading value on its respective construct compared to other constructs. This finding indicates that each indicator consistently represents the construct it is intended to measure. Discriminant validity was also assessed using the Fornell–Larcker criterion by comparing the square root of the Average Variance Extracted (AVE) with the correlations among constructs. The analysis shows that all square root AVE values are higher than the correlations among constructs. The square root AVE values range from 0.876 to 0.877. These results confirm that each construct demonstrates good discriminant validity. Thus, the measurement model meets the adequacy standards to proceed to the structural model analysis.

Reliability testing was conducted using Cronbach's Alpha, Composite Reliability, and Average Variance Extracted. The results show that all constructs have Cronbach's Alpha values above 0.70, specifically 0.902 for Interactive Learning Media, 0.899 for Deep Learning Instruction, and 0.857 for Critical Thinking Skills. The composite reliability values range between 0.80 and 0.90. All AVE values are also above 0.50. These findings indicate that the research instrument demonstrates good internal consistency and high reliability. With these three criteria fulfilled, the instrument is considered reliable and suitable for further analysis.

The evaluation of the structural model indicates that the R-square value for the Critical Thinking Skills variable is 0.931. This value shows that 93.1% of the variance in students' critical thinking skills can be explained by Interactive Learning Media and Deep Learning Instruction. The explanatory power of the model can therefore be categorized as very strong. The remaining 6.9% is influenced by other factors outside the research model. The effect size analysis shows that Interactive Learning Media has an f^2 value of 9.742 on critical thinking skills, which falls into the category of a very strong effect. Meanwhile, the effect of Interactive Learning Media on Deep Learning Instruction has an f^2 value of 0.025, which is categorized as weak.

Hypothesis testing was conducted using the bootstrapping procedure by examining the t-statistics and p-values at a significance level of 5%. The criteria for hypothesis acceptance were established at t-statistics > 1.96 and p-values < 0.05. The bootstrapping results indicate that all relationships among the variables meet the significance criteria. These findings demonstrate that the research hypotheses can be accepted. Overall, the results confirm that interactive learning media play an important role in improving elementary school students' critical thinking skills through the support of integrated deep learning instruction.

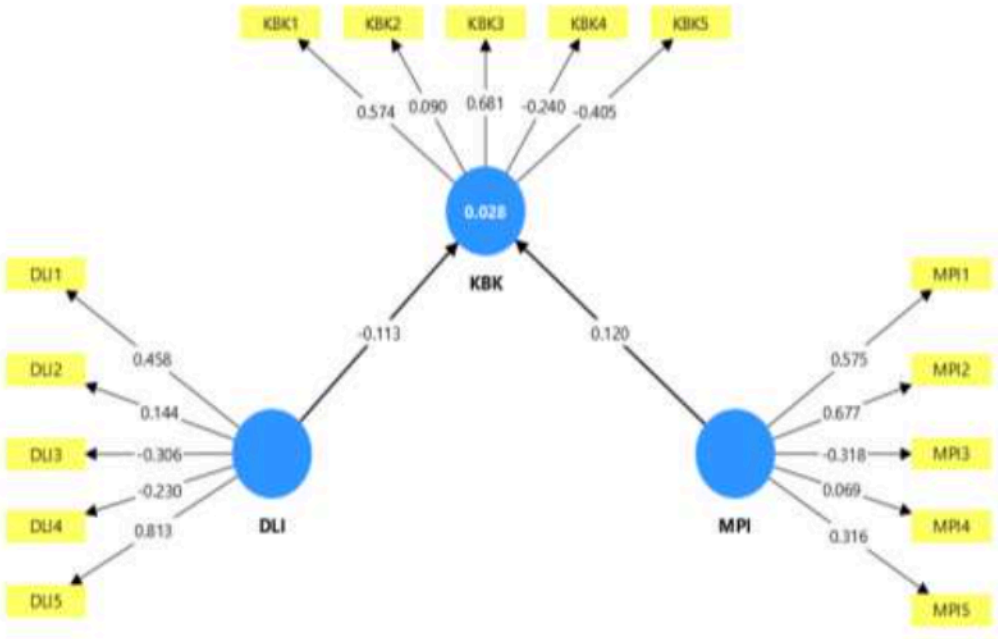

Figure 1. PLS-SEM Model of the Relationship among MPI, DLI, and KBK, Including Path Coefficients and Indicator Loadings.

Based on the data analysis using SmartPLS, the measurement model analysis (*outer model*) shows that the outer loading values for the indicators of the Interactive Learning Media (MPI) variable range from −0.318 to 0.677. Indicator MPI2 has the highest outer loading value of 0.677, indicating the strongest contribution in representing the construct of Interactive Learning Media. Indicator MPI1 also shows a relatively strong contribution with a value of 0.575, followed by MPI5 with 0.316 and MPI4 with 0.069. Meanwhile, indicator MPI3 has the lowest outer loading value of −0.318, indicating a weak contribution in forming the latent construct. These findings suggest that not all indicators of Interactive Learning Media have optimal representational power, implying that the effectiveness of interactive media in learning still depends on specific aspects, particularly those related to the quality of presentation and learning interaction.

For the Deep Learning Instruction (DLI) variable, the outer loading values of the indicators range from −0.306 to 0.813. Indicator DLI5 shows the highest outer loading value of 0.813, indicating that reflection and deeper engagement with learning materials constitute the primary component of the Deep Learning construct. Indicator DLI1 also demonstrates a moderate contribution with a value of 0.458, followed by DLI2 with 0.144. Meanwhile, indicators DLI3 and DLI4 have negative values of −0.306 and −0.230 respectively, indicating relatively weak contributions. These findings suggest that the implementation of deep learning practices has not yet been evenly distributed across all measured dimensions.

The results of the outer model analysis for the Students' Critical Thinking Skills (KBK) variable show that the outer loading values range from −0.405 to 0.681. Indicator KBK3 has the highest outer loading value of 0.681, indicating a dominant role in representing students' critical thinking skills. Indicator KBK1 also demonstrates a relatively strong contribution with a value of 0.574, followed by KBK2 with 0.090. Meanwhile, indicators KBK4 and KBK5 have negative values of −0.240 and −0.405 respectively, indicating weak contributions from these indicators. These results suggest that students' critical thinking skills have not yet developed optimally across all measured aspects.

Based on the results of the structural model (*inner model*) analysis, the path coefficient shows that Deep Learning Instruction (DLI) has a direct effect on Critical Thinking Skills (KBK) with a value of −0.113. This value indicates that the effect of DLI on KBK is weak and tends to be negative. Interactive Learning Media (MPI) also shows a weak direct effect on KBK with a path coefficient value of 0.120. These findings indicate that both interactive learning media and deep learning instruction have not yet demonstrated a strong direct influence on improving elementary school students' critical thinking skills.

The R-Square (R^2) value for the Critical Thinking Skills variable is recorded at 0.028. This value indicates that the combination of Interactive Learning Media and Deep Learning Instruction explains only 2.8% of the variance in students' critical thinking skills, while 97.2% is influenced by other factors outside the research model. This low R-Square value indicates that critical thinking skills represent a complex construct influenced by many other factors, such as teachers' instructional strategies, the learning environment, student characteristics, and social support within the school context.

Overall, the analysis results indicate that although Interactive Learning Media and Deep Learning Instruction have potential in supporting the learning process, their direct influence on elementary school students' critical thinking skills remains relatively limited. These findings emphasize that the use of interactive media and the implementation of deep learning need to be combined with instructional strategies that are more oriented toward analytical, reflective, and collaborative activities in order to generate a more significant impact on the development of students' critical thinking skills.

The integration of interactive learning media within deep learning instruction in this study demonstrates a facilitative role but does not yet produce a strong direct effect on the critical thinking skills of elementary school students. This is reflected in the path coefficient values of Interactive Learning Media → Critical Thinking Skills of 0.120 and Deep Learning Instruction → Critical

Thinking Skills of −0.113, both of which indicate relatively weak effects. These findings suggest that the use of interactive media does not automatically enhance students' critical thinking abilities; rather, its effectiveness largely depends on the quality of instructional design, the strategies used in its implementation, and the extent to which it is integrated into the learning process.

At the elementary school level, students still require intensive guidance to develop higher-order thinking processes optimally and sustainably (Wafa & Nadhif, 2025). Interactive learning media has the potential to help students understand concepts more concretely through visualization, simulations, and direct interaction (Mazna et al., 2024). However, the results of this study indicate that when interactive media is not optimally integrated into deep learning scenarios, it tends to encourage engagement primarily at the surface level. Under such conditions, learning activities tend to focus more on responding to media presentations rather than engaging in analysis, evaluation, and reflection, which constitute the core components of critical thinking skills.

Deep learning emphasizes conceptual understanding, the interconnection of ideas, and students' ability to explain and reflect on their understanding systematically (Bulan et al., 2025). The findings of this study indicate that deep learning practices in the classroom have not yet consistently provided sufficient opportunities for students to develop critical thinking processes. This is reflected in the variation in the outer loading values of the DLI indicators, which still show uneven contributions, with several indicators displaying low or negative values. Learning activities still tend to focus on task completion and achieving correct answers, thereby limiting students' opportunities to explore reasoning, compare alternatives, and draw conclusions independently. This condition indicates that deep learning has not yet been fully implemented as a process that consistently encourages higher-level cognitive exploration.

The coefficient of determination (R^2) value of 0.028 indicates that Interactive Learning Media and Deep Learning Instruction explain only a small portion of the variance in students' critical thinking skills. This finding suggests that the critical thinking skills of elementary school students are influenced by many other factors beyond the variables included in the research model, such as teachers' pedagogical competence, the quality of learning interactions, students' cognitive developmental characteristics, and learning environments that support reflective and dialogic processes. These factors play a crucial role in shaping students' critical thinking habits gradually and sustainably.

Overall, the results of this study emphasize that the development of students' critical thinking skills cannot rely solely on the use of interactive learning media and the implementation of deep learning instruction. Both approaches need to be integrated with pedagogical strategies that explicitly promote analytical, argumentative, reflective, and collaborative activities. A comprehensive and sustainable approach therefore becomes an essential prerequisite for enabling interactive media and deep learning to function optimally in fostering the critical thinking skills of elementary school students.

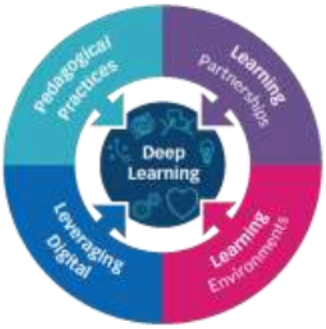

Figure 2. Deep Learning Framework in the Development of Elementary School Students' Critical Thinking

The figure represents deep learning as a system composed of pedagogical practices, learning partnerships, learning environments, and the utilization of digital technology that are interconnected. This framework indicates that interactive learning media serve only as one supporting component within the broader process of deep learning. Without the support of instructional practices that

encourage analytical and reflective activities, a conducive learning environment, and meaningful learning interactions, the use of interactive media tends to be insufficient in optimizing the development of students' critical thinking skills. This understanding reinforces the importance of the teacher's role in designing and pedagogically integrating learning media so that it truly functions as a facilitator of deep learning.

Deep learning emphasizes conceptual mastery, the interconnection of ideas, and students' ability to explain and reflect on their understanding systematically. The findings of this study indicate that the implementation of deep learning in the classroom has not yet been fully consistent in providing adequate opportunities for the development of students' critical thinking skills. Learning activities still tend to focus on task completion and achieving correct answers, thereby limiting students' opportunities to explore reasoning, compare alternative solutions, and draw conclusions independently. The low coefficient of determination also indicates that the critical thinking skills of elementary school students are influenced by various factors beyond the use of interactive media and deep learning instruction. These factors include teachers' pedagogical competence, patterns of learning interaction, students' cognitive developmental characteristics, and learning environments that support reflective thinking processes.

Although the direct influence of interactive learning media on critical thinking skills is relatively weak, the media still plays a strategic role as a supporting tool in the learning process. Interactive media can become an effective instrument when used to facilitate higher-order thinking activities, such as observing phenomena, analyzing information, connecting concepts, and reflecting on learning outcomes. Without careful pedagogical planning, media may only function as an attractive visual element without making a meaningful contribution to the quality of students' thinking. In this context, the teacher's role becomes crucial in optimizing the function of interactive media within deep learning. Teachers need to design learning activities that encourage students to actively ask questions, express ideas, and evaluate information obtained through the media. Open-ended questions, exploratory tasks, and reflective activities should be systematically designed so that interactive media truly supports the development of critical thinking skills.

Overall, the results of this study confirm that interactive learning media and deep learning instruction are not single factors that directly determine the critical thinking skills of elementary school students. Both function as facilitators whose effectiveness largely depends on the quality of instructional planning, learning strategies, and teacher guidance. These findings imply that improving students' critical thinking skills requires a more comprehensive integration of learning media, instructional strategies, and pedagogical practices oriented toward the continuous development of higher-order thinking processes.

CONCLUSION

This study demonstrates that interactive learning media and deep learning instruction function as facilitators in the development of elementary school students' critical thinking skills, although they have not yet produced a strong direct effect. The results of the analysis using SmartPLS indicate that the effectiveness of interactive media largely depends on the quality of instructional design and the pedagogical strategies implemented by teachers. The inconsistent implementation of deep learning practices also emerges as a factor that limits the optimal development of students' higher-order thinking processes.

These findings emphasize that the development of critical thinking skills cannot rely solely on the use of learning media or specific instructional approaches. Instead, it requires a well-integrated combination of media utilization, instructional strategies, and continuous teacher guidance. Therefore, teachers need to design learning activities that are oriented toward analytical, reflective, and dialogic engagement so that interactive learning media can function optimally in supporting deep learning and fostering the development of elementary school students' critical thinking skills.

DECLARATION OF AI AND AI ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work the author(s) used [NAME TOOL / SERVICE] in order to [REASON]. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

AUTHORS' CONTRIBUTION

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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