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Development of a Technology-Based Cooperative Learning Model to Improve Elementary Students' Critical Thinking Skills

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Abstract

The rapid development of digital technology requires elementary schools to provide learning experiences that foster critical thinking skills from an early age. However, instructional practices in many elementary classrooms are still dominated by teacher-centered approaches, which limit student engagement and opportunities for higher-order thinking. This study aims to develop and validate a technology-based cooperative learning model that aligns with the characteristics of elementary school students and is oriented toward enhancing critical thinking skills. This research employed a Research and Development (R&D) approach, consisting of a preliminary study, model design, expert validation, revision, and a limited field trial involving fifth-grade students. The developed model integrates cooperative learning strategies, specifically Think-Pair-Share and Jigsaw, supported by digital technologies such as Google Classroom, Padlet, and Kahoot, to facilitate collaboration, reflective discussion, and formative assessment. Research instruments included expert validation sheets, observation checklists, and critical thinking skills tests.The validation results indicate that the developed model is highly valid and feasible for implementation. The field trial results demonstrate increased student engagement, improved conceptual understanding, and higher critical thinking scores compared to previous instructional conditions. These findings suggest that the technology-based cooperative learning model has strong potential to support the development of critical thinking skills in elementary education and provides a practical framework for teachers to integrate technology into classroom instruction.

Keywords: cooperative learning; critical thinking; elementary school; technology integration

Introduction

The development of critical thinking skills has become a central priority in 21st-century education, as it enables students to analyze information, evaluate arguments, and solve problems systematically (Trilling & Fadel, 2009; OECD, 2020). Recent global research shows that digital-supported collaboration significantly fosters higher-order thinking and active learning environments (Hwang & Tsai, 2011;Wong & Chai, 2020). However, large-scale international assessments such as the Programme for International Student Assessment (PISA) reveal that Indonesian students' ability to apply critical and creative thinking remains below the OECD average. The most recent PISA 2022 report

placed Indonesia 72nd out of 81 participating countries in reading literacy and 71st in mathematics, indicating persistent challenges in higher-order thinking and problem-solving (OECD, 2020). Similar issues occur in Asian primary schools where cooperative learning is under-utilized (Kim & Park, 2021; Rahmat, 2022). These findings underscore the urgency of improving students' reasoning and analytical skills from the early stages of schooling.

In the Indonesian elementary school context, national and local studies consistently report that students' critical thinking skills are relatively low and insufficiently nurtured in classroom learning (Samsuri & Firdaus, 2017; Yulianti & Haryanto, 2020). Recent systematic reviews also emphasize that technology-enhanced collaborative inquiry can effectively foster higher-order thinking and student engagement when digital tools are aligned with cooperative activity design (Chen & Huang, 2023); (Liu et al., 2019). Cooperative learning studies in Southeast Asia emphasize its importance, yet few models systematically integrate digital tools to strengthen critical thinking in primary education settings (Kurniawati, 2022; Yusuf, 2021). Many learning activities remain teacher-centered, with limited opportunities for students to question, argue, and construct their own understanding. This condition can hinder students' capacity to make informed decisions, evaluate multiple perspectives, and apply knowledge to real-life problems (Gillies, 2016). Thus, fostering critical thinking at the elementary level requires pedagogical models that actively engage students in collaborative exploration and reflective discussion. This argument is further supported by (Guo et al., 2024), who propose an instructional model grounded in collaborative and reflective learning. Their findings demonstrate that structured collaborative exploration and reflective discussion play a crucial role in enhancing students' analytical and critical thinking skills.

In the context of Indonesian elementary schools, learning activities are still dominated by teacher-centered approaches, limited student interaction, and minimal use of digital tools that support exploratory learning. These conditions hinder the development of critical thinking skills in children aged 9–11, who are in the concrete operational stage and require structured interaction, visual scaffolds, and guided collaboration (Hayat et al., 2024). Although previous studies have implemented cooperative learning or digital platforms in isolation, research integrating both

approaches specifically for elementary school settings remains limited. This gap indicates the importance of developing a technology-supported cooperative learning model tailored to the cognitive, social, and technological readiness of primary school students (Q. Wang, 2019).

One promising pedagogical approach is cooperative learning, which allows students to work together, exchange ideas, and jointly construct understanding through structured group activities (Johnson & Johnson, 2018). Research shows that cooperative learning enhances academic achievement, social interaction, and higher-order thinking (Slavin, 2015; Johnson & Johnson, 1987). Techniques such as Think-Pair-Share, Jigsaw, and Group Investigation have been widely recognized for promoting engagement and deep learning (Azisah et al., 2023). However, the application of cooperative learning in Indonesian elementary schools still faces several challenges, particularly limited integration with digital tools and the lack of systematic technological support in lesson design (Rachman et al., 2017).

In recent years, technology integration has increasingly supported cooperative learning dynamics by facilitating peer interaction, collaborative knowledge construction, and formative feedback. Digital platforms enable students to share ideas, organize information collectively, and reflect on group outcomes, thereby strengthening social interaction and metacognitive processes required for higher-order thinking (Lai & Hwang, 2016; Setiawan, 2023). In elementary education contexts, tools such as Google Classroom and Padlet have been shown to increase engagement and participation, while gamified digital quizzes improve student motivation and immediacy of feedback (Gunawan, 2022; Su & Cheng, 2023). When technology is purposefully aligned with cooperative structures, it supports meaningful collaboration and enhances critical thinking outcomes, particularly when teachers provide clear guidance and scaffolding throughout the learning cycle (Fu & Hwang, 2020; Chen & Huang, 2023).

This study positions technology not as a replacement for teacher-guided cooperative learning, but as a supportive medium that amplifies interaction, feedback, and student accountability in group-based tasks. Such alignment is essential in elementary classrooms, where structured scaffolding and guided collaboration remain key to building foundational critical thinking skills.

At the same time, advances in educational technology have created opportunities to design more interactive, student-centered learning environments (Kerimbayev et al., 2023). Tools such as Google Classroom, Padlet, and Kahoot can facilitate collaboration, feedback, and formative assessment in ways that stimulate students' curiosity and motivation (Wulandari & Pratama, 2021). Nevertheless, existing studies in Indonesia often treat cooperative learning and technology integration as separate efforts—some focus on digital platforms without clear pedagogical scaffolding, while others apply cooperative strategies without digital support (Suwandi et al., 2022). This fragmentation indicates a clear research gap: the absence of a contextualized, validated model that integrates cooperative learning principles with educational technology to enhance critical thinking among elementary students.

In addition to the theoretical gap identified in the literature, the need for developing this instructional model is also supported by empirical conditions in elementary schools. A preliminary study conducted by the researcher through classroom observations and informal interviews with teachers in several nearby elementary schools revealed that instructional practices remain largely teacher-centered, with limited pedagogical integration of digital technology. Collaborative learning activities are often implemented superficially and are not systematically designed to promote reflective discussion or critical thinking skills. Teachers also reported difficulties in identifying practical instructional models that effectively integrate cooperative learning principles, technology use, and critical thinking assessment. These findings indicate a clear practical need for a contextualized and validated technology-based cooperative learning model to support the development of students' critical thinking skills at the elementary level.

In response to this gap, the present study aims to develop and validate a technology-based cooperative learning model designed to improve elementary school students' critical thinking skills. While previous studies in Indonesia examined cooperative learning or digital tools separately, few have integrated both approaches within the same instructional design - particularly in Islamic and primary education contexts (Rahman et al., 2022 ; Salija et al., 2024). This gap highlights the urgency of developing a model that contextualizes digital cooperative learning to Indonesian classrooms. The proposed model combines cooperative learning structures such as Think-Pair-Share and Jigsaw with digital platforms that facilitate interaction, reflection, and

assessment. This study contributes to the growing literature on technology-supported pedagogy by providing empirical evidence and a practical framework for integrating cooperative and digital learning in the Indonesian elementary education context.

The conceptual framework of this study is presented in Figure 1, which illustrates the flow from problem identification, theoretical review, model development, classroom implementation, data analysis, and the final validated model.

The purpose of this study is to develop and validate a technology-based cooperative learning model designed to improve the critical thinking skills of elementary school students. Specifically, this study aims to: (1) design an effective model that integrates cooperative learning strategies and digital tools; (2) test its effectiveness in improving students' critical thinking skills in IPS subjects; and (3) analyze teachers' and students' responses to its.

The conceptual framework developed in this study illustrates the logical flow of the research process, starting from the identification of problems and theoretical review to model development, classroom implementation, and validation.

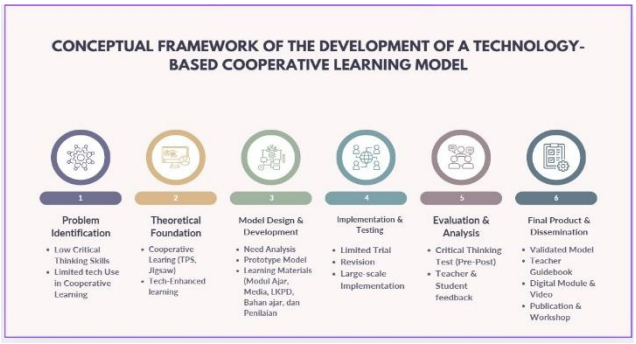

Figure 1 : Conceptual Framework of the Development of a Technology-Based Cooperative Learning Model

Source: Processed by Researcher (2025)

Figure 1 provides a visual representation of the conceptual framework that guided the design and validation of the technology-based cooperative learning model, serving as the foundation for the subsequent research methods.

Methods

This study utilized the Research and Development (R&D) approach as outlined by Borg and Gall (1983), which involves six key stages: needs analysis, model development, expert validation, limited trial, large-scale implementation, and

dissemination (Sinaga et al., 2023). Incorporating recent practitioner recommendations, each phase was enhanced with digital components such as online collaboration and formative feedback tools, ensuring alignment between cooperative pedagogy and technological scaffolding (Rahmadani et al., 2025). The choice of cooperative learning strategies and digital tools was intentionally designed to match the developmental characteristics of elementary students, who require clear task structures, peer support, and visual prompts to maintain engagement. Think-Pair-Share was employed to foster guided reasoning, while Jigsaw was used to encourage structured interdependence, making it suitable for students aged 9–10 (Achuonye et al., 2024). Digital platforms such as Google Classroom, Padlet, and Kahoot were selected because they provide accessible scaffolding for young learners, enabling teachers to monitor student participation and understanding in real time.

Participants were selected using a purposive sampling technique, targeting elementary schools in the Yogyakarta Special Region that met specific criteria: (1) schools with adequate ICT infrastructure (computers, internet access, and digital learning facilities), (2) schools located in the Yogyakarta Special Region, and (3) teachers willing to collaborate in the implementation of technology-based cooperative learning. The limited trial phase included two schools with 56 fourth-grade students, while the large-scale implementation involved nine schools with 261 students and nine teachers. In each school, a classroom teacher co-facilitated the implementation under the researchers' guidance.

Data were collected using four instruments: validation sheets, which were completed by three experts in curriculum design, educational technology, and cooperative learning to assess the model's validity; observation sheets, which recorded classroom interactions and student engagement; interview guidelines, which were administered to teachers and selected students to obtain qualitative feedback on the practicality, clarity, and motivational impact of the activities; and critical thinking tests (pre-test and post-test) to measure improvements in students' critical thinking skills. All data collection procedures adhered to ethical standards, with permissions obtained from school principals, teachers, and parents. Teachers were introduced to the instruments through a brief training session to ensure consistent implementation, and researchers provided ongoing support for managing the digital platforms during each session.

The study employed a systematic Research and Development (R&D) approach, comprising six stages: preliminary analysis, model development, limited trial, model evaluation and revision, large-scale implementation, and dissemination (C. Wibowo et al., 2024). During the preliminary analysis, needs assessments were conducted across 11 elementary schools in Yogyakarta, Indonesia, involving 317 fourth-grade students to identify gaps in current cooperative learning practices. Based on the findings, a Technology-Based Cooperative Learning Model integrating Think-Pair-Share and Jigsaw strategies with digital tools like Google Classroom was developed.

The model was then tested in a limited trial at two schools with 56 students over two weeks, focusing on critical thinking skills. Following analysis of the trial data, revisions were made, and the model was implemented on a larger scale in nine schools with 261 students, gathering data through student assessments, teacher reflections, and classroom observations. The final validated and refined model was documented in the final research report and prepared for academic dissemination. Ethical considerations were strictly observed, with informed consent obtained from all stakeholders to ensure confidentiality and compliance with research standards in elementary school settings.

Result

First, Expert Validation Results

The prototype model was thoroughly evaluated by three experts in elementary education, who assessed the lesson plan (RPP), digital student worksheet (LKPD), and model implementation guide using a four-point Likert scale (1 = very poor, 4 = very good). The results revealed strong agreement among the experts, with an overall mean score of 3.7, indicating that the components of the model were deemed "very valid" and suitable for classroom implementation. Specifically, the learning model guide received a mean score of 3.7, categorizing it as "very valid," while the lesson plan (RPP) was rated as "valid" with a mean score of 3.6. The digital worksheet (LKPD) and observation sheet both scored highly at 3.8 and 3.7, respectively, categorizing them as "very valid." T

hese expert validation results underscore the robustness and pedagogical alignment of the model, reflecting its potential for effective implementation in digital cooperative learning environments. The findings are consistent with prior research, which emphasizes the importance of systematic expert validation to ensure the soundness of

instructional models and their alignment with educational objectives, as highlighted by (Cabero-Almenara & Palacios-Rodríguez, 2021). This validation not only confirms the appropriateness of the model for classroom use but also sets the foundation for further refinement and scaling in future educational settings.

Table 1: Expert Validation Results of the Prototype Model

Component	Expert 1	Expert 2	Expert 3	Mean Score	Category
Learning Model Guide	3.6	3.8	3.7	3.7	Very Valid
Lesson Plan (RPP)	3.5	3.7	3.6	3.6	Valid
Digital Worksheet (LKPD)	3.7	3.8	3.8	3.8	Very Valid
Observation Sheet	3.6	3.7	3.8	3.7	Very Valid
Overall	3.6	3.75	3.7	3.7	Very Valid

Source: Expert validation data processed by researchers (2025).

Research on the development of instructional models, particularly in digital cooperative learning settings, consistently highlights the critical role of systematic expert validation in ensuring both content soundness and pedagogical alignment. (Cabero-Almenara & Palacios-Rodríguez, 2021) emphasize that expert validation is vital for confirming the instructional design's coherence with educational goals, the accuracy of the content, and the applicability of the strategies in diverse classroom environments. They suggest that expert feedback not only improves the quality of the learning materials but also helps identify potential areas of improvement, ensuring that the model is both effective and adaptable to various educational contexts.

Similarly, (Alzahrani, 2022) stresses that expert validation provides essential insights into the model's practical feasibility and instructional integrity. By involving experts in curriculum design, educational technology, and pedagogy, the validation process strengthens the model’s potential to foster student engagement and critical thinking, especially in digital learning environments. Alzahrani’s findings underline that a model validated by experts ensures that digital tools and strategies are aligned with the developmental needs of students, enhancing the learning experience and improving educational outcomes.

These studies align with the current research, supporting the notion that expert validation is an indispensable step in the development of instructional models (Lee et al., 2017). This perspective is consistent with the view proposed by (Dick et al., 2015), who

argue that instructional design validation aims to examine the alignment among learning objectives, instructional materials, strategies, and evaluation components to ensure that the developed model functions effectively and consistently. Their findings reinforce the importance of ensuring that instructional models are not only pedagogically sound but also integrated effectively with digital tools to create a holistic, engaging, and supportive learning environment. Through expert validation, educational practitioners can refine their models to meet the evolving needs of students in an increasingly digital world.

Second, Development Process and Product Improvement

The development process of the Technology-Based Cooperative Learning Model aimed at improving elementary students' critical thinking skills involved several iterative revisions to ensure its effectiveness and usability in real classroom settings. Early trials revealed that some instructions in the Digital Student Worksheet (LKPD) were too lengthy, leading to student confusion when engaging with digital tools such as Padlet and Kahoot. Teachers noted that students struggled to follow these instructions and that more clear and structured guidance was needed to facilitate smooth interactions with the technology. In response to this feedback, the instructions were simplified and broken down into clearer, more manageable steps. Additionally, examples were added to provide better context, and group-task prompts were made more explicit to guide students through the activities. These revisions were aimed at enhancing students' ability to engage with the tools effectively and at improving the clarity of the tasks, which, in turn, boosted their participation and understanding during the cooperative activities.

The prototype was tested through short implementation cycles, each followed by a thorough analysis of student worksheets, observation notes, and teacher reflections. This data collection provided valuable insights into student interactions, the role of digital tools in supporting collaborative learning, and areas that required further refinement. Observations indicated that students were more engaged when tasks were clearly outlined and when they had immediate feedback from tools like Kahoot, which provided real-time interaction. Moreover, the group work became more structured and productive, as the clarity of instructions and the use of digital platforms facilitated smooth collaboration. These observations confirmed the need for continual model adjustments to ensure that it was adaptable to the diverse needs of elementary students. Each cycle of implementation and analysis led to targeted revisions that progressively improved the model's usability

and effectiveness. The iterative development process not only refined the model but also ensured that it was aligned with the intended goal of enhancing students' critical thinking skills through cooperative learning. As a result, the final version of the model demonstrated a significant improvement in student engagement, participation, and critical thinking, making it a promising approach for future use in elementary education.

Third, Evidence of Model Implementation

During the small-group trials, students actively engaged with the digital tools Padlet and Kahoot to enhance their cooperative learning experience. Padlet was used as a brainstorming platform where students could collaboratively generate and organize ideas in real time, fostering a sense of shared ownership over the learning process. This digital tool encouraged students to interact with each other, exchange perspectives, and build upon one another's contributions, thus reinforcing the principles of cooperative learning (Salija et al., 2024). Kahoot, on the other hand, was employed as a formative assessment tool to measure students' understanding of the material (A. I. Wang & Tahir, 2020). It provided immediate feedback, allowing teachers to gauge the effectiveness of the lesson in real time and make on-the-spot adjustments to the teaching approach if necessary.

Teachers played a pivotal role in monitoring the interactions within the groups, using detailed observational notes to track how students applied cooperative learning roles, such as leadership, collaboration, and task management. These observations provided valuable insights into the dynamics of group work, highlighting areas where students excelled and where they encountered challenges. Based on structured observational indicators, most students demonstrated active participation, idea clarification, and collaborative engagement during group discussions, with observational scores predominantly falling within the "good" to "very good" categories. These observable behaviors indicate that the instructional model's structure, supported by digital tools, effectively facilitated student interaction and reinforced cooperative roles essential for critical thinking development. This finding is consistent with (Koh et al., 2017), who argue that pedagogically grounded technology integration based on the TPACK-21CL framework enables teachers to design learning experiences that go beyond mere tool usage, fostering 21st-century skills such as collaboration, communication, and critical thinking

Figure 2: Students practice using the technology provided by the team

Source: research personal data

The following visual documentation, shown in Figure 2, captures a moment from the implementation stage, where students are collaboratively completing the digital worksheet (LKPD) using the cooperative learning model. This image illustrates not only the use of technology but also the active collaboration and problem-solving that were integral to the learning process. The students are seen engaging with the worksheet, with each group member contributing ideas and discussing solutions, demonstrating the model's impact on fostering cooperative engagement and enhancing critical thinking skills. This real-time interaction underscores the potential of combining digital tools with cooperative learning strategies to create an interactive and effective learning environment for elementary students

Fourth, Data Processing Summary

The data processing for this study involved a comprehensive analysis of both quantitative and qualitative data to assess the effectiveness and feasibility of the Technology-Based Cooperative Learning Model. Quantitative data, primarily derived from expert validation scores and student worksheet results, were analyzed using descriptive statistics. This approach provided an overall view of how well the model met the required standards for classroom implementation. The expert validation results, which were based on a four-point Likert scale, indicated high levels of agreement among the evaluators regarding the validity of the lesson plans, digital worksheets, and model guides, with mean scores ranging from 3.6 to 3.8, classifying them as "very valid" and "valid." These scores provided evidence that the model's content was appropriate and effective for the intended educational context, offering strong support for its feasibility in promoting student engagement and critical thinking.

In addition to the quantitative analysis, qualitative data were gathered from teacher reflections, student interviews, and classroom observations. These qualitative data were carefully coded into recurring themes such as the clarity of instructions, digital engagement, and group collaboration. Teacher reflections provided valuable insights into the practical implementation of the model, highlighting areas where students excelled and where further adjustments were needed. For instance, teachers noted that simplifying instructions and providing clearer task prompts significantly improved student understanding and participation during cooperative activities. Observations of classroom interactions revealed how the digital tools, such as Padlet and Kahoot, enhanced student engagement, encouraging active collaboration and real-time feedback. Furthermore, interviews with students revealed their perceptions of the learning process, indicating that the digital tools made learning more interactive and enjoyable, which in turn motivated them to engage more deeply with the tasks.

The triangulation of both quantitative and qualitative data ensured the credibility and consistency of the findings (Abrar et al., 2024). By cross-referencing the results from the expert validation, student performance on the worksheets, and the insights gathered from teacher and student feedback, the study was able to draw robust conclusions about the model's effectiveness. The convergence of these data sources affirmed that the Technology-Based Cooperative Learning Model successfully promoted student collaboration, improved engagement with digital tools, and enhanced critical thinking skills. This thorough data processing not only validated the model's feasibility but also provided actionable insights for refining the instructional design for future classroom applications. The consistent patterns identified across the data sources strengthen the argument that the model is a valuable pedagogical tool that can be effectively utilized in elementary education to foster cooperative learning and critical thinking.

Discussion

The development of this technology-based cooperative learning model aims to address two key issues identified in the initial analysis: low student engagement and limited opportunities for elementary school students to practice critical thinking skills. Based on findings obtained during the implementation phase, this model has proven successful in encouraging active student participation through structured group roles and

digital scaffolding. Students were more engaged in explaining ideas, negotiating answers, and evaluating group outcomes—behaviors that align with cooperative learning theory and the socio-constructivist perspective. This indicates that the implementation of this model has met the initial objectives of this study, namely increasing student engagement in the learning process and developing their critical thinking skills.

One key aspect addressed by this model is low student engagement in learning, a common problem in many elementary classrooms. This study found that the use of a technology-based cooperative learning model successfully increased student engagement in various learning activities. Structured roles within groups, such as leader, note-taker, or timer, provided opportunities for each student to actively contribute to group discussions. This supports cooperative learning theory, which emphasizes the importance of social interaction and collaboration to enhance material comprehension (Gareth & Jinting, 2025).

Students are not only engaged in physical activities or completing assignments, but also engage in more critical thinking processes. They engage in activities such as explaining their reasoning, discussing answers with their group mates, and evaluating their results. These activities are closely linked to the principles of Vygotsky's social constructivism theory, which emphasizes the importance of social interaction in cognitive development (Dewi & Elisa, 2025). This perspective is further supported by recent studies in collaborative learning, which highlight that structured social interaction in learning environments, particularly when facilitated by instructional design and digital learning tools, plays a critical role in fostering higher-order thinking and meaningful knowledge construction (Hämäläinen et al., 2015). In this case, technology serves as a tool to strengthen this social interaction, allowing students to share ideas, receive immediate feedback, and develop their understanding within a social context.

One of the key findings of this study is the use of technology in the developed learning model, which has proven effective in supporting reflective thinking and the development of higher-order thinking skills (Su & Cheng, 2023). The use of Padlet and Kahoot provides real-time feedback and supports students' critical thinking. Padlet, as a collaborative platform, allows students to simultaneously organize and visualize their ideas, provides a space for them to collaborate on solutions, and provides an opportunity for them to see and respond to their peers' opinions.

In fact, the formative assessment tool offers a mechanism for providing feedback to students. The use of this model not only provides an opportunity for students to gauge their understanding but also introduces a healthy element of competition, which encourages deeper engagement. Through immediate feedback, students can identify their errors, discuss their answers in groups, and refine their understanding. This aligns with the principles of Bloom's theory, which emphasizes the importance of students' active involvement in self-evaluation to develop critical thinking skills.

The results of this study indicate that the use of technology in cooperative learning can increase student engagement and support the development of their critical thinking skills. This aligns with the cooperative learning theory proposed by (Johnson & Johnson, 1998), which states that cooperative learning leads to better development of social and cognitive skills when students work in groups toward a common goal. By adding digital elements to the learning process, as done in this model, technology provides additional tools that enrich students' learning experiences and strengthen cooperative learning theory.

Furthermore, this research also supports the constructivist perspective pioneered by Piaget and Vygotsky, which emphasizes the importance of social and collaborative experiences in learning (Miao & Nduneseokwu, 2025). Vygotsky, in particular, emphasized that effective learning occurs within the zone of proximal development (ZPD), where students learn with the assistance of more skilled others, such as their group mates (S. Wibowo et al., 2025). In this context, digital technologies such as Padlet and Kahoot serve as tools that support the ZPD by providing scaffolding that allows students to learn from each other in a more dynamic and interactive environment.

This learning model offers several practical advantages for elementary classrooms. One is the structured steps within the model that help teachers guide group interactions more effectively. By clearly assigning roles within groups, teachers can more easily manage group dynamics and ensure that every student is engaged in the learning process. Technology-based learning also increases student engagement with the material (Adipat et al., 2021). Digital tools like Padlet and Kahoot make learning more fun and interactive, which in turn increases student motivation and engagement.

Furthermore, this model is highly flexible and adaptable to a variety of subjects and skill levels, making it applicable across a variety of classroom contexts. The use of

easily accessible digital tools also allows this model to be implemented in a variety of schools, despite variations in the availability of devices and technological infrastructure. Thus, this model is not only suitable for enhancing critical thinking skills but also offers a practical solution for improving the quality of learning in elementary schools in general.

While several aspects of this model offer numerous advantages, several limitations need to be considered. One is the reliance on adequate devices and a stable internet connection. The availability of adequate devices and smooth internet access are crucial for the success of this model, but not all schools have sufficient resources. Furthermore, some students require additional guidance when using digital tools for the first time. The use of this new technology can present technical challenges that teachers need to overcome to ensure students can access and utilize the technology effectively.

Another limitation is the limited time required for learning, which often limits opportunities for students to engage in in-depth group discussions. Sometimes, within a short time, group activities become rushed, and opportunities for further development of ideas are limited. Therefore, future development of this learning model could explore simpler digital alternatives, longer implementation periods, or teacher training modules to support more consistent use of this model.

Conclusion

This study successfully developed a technology-based cooperative learning model that is both suitable for elementary school contexts and effective in improving students' critical thinking skills. The R&D process resulted in a highly valid model, confirmed by expert evaluations, and demonstrated its applicability in real classroom settings. The findings from the field tests showed that the model positively impacted the learning process, with students becoming more active, engaged in meaningful discussions, and demonstrating clearer articulation of their reasoning. In addition, the research findings indicate that the developed instructional model has the potential to support the development of students' critical thinking skills.

Despite these positive outcomes, there are some limitations to the model. Its success is dependent on the availability of digital devices and reliable internet connectivity, which may not be consistently present in all schools. Additionally, the model's effectiveness relies on teachers' readiness to integrate digital tools into their

teaching practices, which may vary across different educational settings. To address these challenges, future research should explore ways to implement the model in schools with limited resources, potentially by simplifying the digital tools used or incorporating offline alternatives. Furthermore, teacher training programs should be developed to help educators effectively use the model and integrate cooperative learning strategies with digital tools.

Moving forward, it is recommended that the model be tested on a larger scale to validate its effectiveness across different schools and contexts. Research should also examine the long-term impact of the model on students' 21st-century skills, such as collaboration, problem-solving, and communication. By addressing these limitations and refining the model for broader use, future studies could contribute to improving the quality of education and preparing students for the challenges of the modern world.

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