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The Effects Of Game Type (Traditional Vs. Modern) On Critical Thinking Skills Of Elementary School Students

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Abstrak

Berpikir kritis (CT) merupakan keterampilan utama abad ke-21 yang perlu dikembangkan sejak dini, khususnya pada tahap perkembangan sensitif di akhir masa kanak-kanak. Penelitian ini membandingkan efektivitas pembelajaran berbasis permainan tradisional dan modern dalam mengembangkan CT pada siswa Indonesia berusia 9 hingga 10 tahun. Dengan menggunakan desain crossover seimbang 2x2, sebanyak 54 peserta memainkan permainan papan tradisional yang dimodifikasi (Catur Jawa) dan permainan robotik modern. Hasil CT diukur menggunakan versi adaptasi dari Cornell Critical Thinking Test. Hasil menunjukkan tidak terdapat perbedaan yang signifikan secara statistik dalam peningkatan CT antara permainan tradisional (M = 3,20, SD = 1,24) dan permainan modern (M = 2,83, SD = 1,45), $F(1,52)$ = 3,13, p = 0,083. Efek urutan dan interaksi juga tidak signifikan. Temuan ini menguji asumsi bahwa permainan digital secara inheren lebih unggul, dan menekankan bahwa desain instruksional, bukan teknologi, merupakan faktor utama dalam pengembangan CT. Kebaruan studi ini terletak pada fokusnya pada pendidikan dasar serta dukungannya terhadap pergeseran pengembangan permainan edukatif dari pendekatan berorientasi teknologi ke pendekatan berorientasi desain. Keterbatasan penelitian ini adalah rentang usia yang sempit dan jenis permainan yang terbatas. Penelitian selanjutnya perlu mengkaji fitur desain instruksional tertentu dalam berbagai format untuk memahami faktor yang mendorong efektivitas pembelajaran.

Kata Kunci: berpikir kritis, pembelajaran berbasis permainan, permainan modern, permainan tradisional.

Abstract

Critical thinking (CT) is a key 21st-century skill that should be cultivated early, especially during the sensitive developmental stage of late childhood. This study compares the effectiveness of traditional and modern game-based learning in fostering CT among Indonesian students aged 9 to 10 years. Using a 2x2 counterbalanced crossover design, 54 participants engaged in both a modified traditional board game (Catur Jawa) and a modern robotic game. CT outcomes were measured using an adapted version of the Cornell Critical Thinking Test. Results showed no statistically significant difference in CT improvement between the traditional game (M = 3.20, SD = 1.24) and the modern game (M = 2.83, SD = 1.45), $F(1,52)$ = 3.13, p = .083. Sequence and interaction effects were also non-significant. These findings challenge the assumption that digital games are inherently superior, emphasizing that instructional design, not technology, is the key driver of CT development. The novelty of this study lies in its focus on primary education and its support for shifting educational game development from technology-centric to design-centric approaches. A limitation of this study is its narrow age range and limited game types. Future research should examine specific instructional features across diverse formats to gain a better understanding of what drives effective learning.

Keywords: *critical thinking, game-based learning, modern games, traditional games.*

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INTRODUCTION

Critical thinking (CT) is a foundational 21st-century competency essential for navigating complex, information-rich environments. Its early cultivation is particularly crucial in primary education, as this developmental period is recognized as a key window for acquiring higher-order cognitive skills. In response, game-based learning (GBL) has emerged as a promising pedagogical approach, leveraging problem-solving cycles and intrinsic motivation to engage learners in cognitively demanding tasks (Plass et al., 2020).

A persistent theoretical dichotomy exists within GBL literature: traditional physical games (e.g., strategy-based board games) are championed for promoting CT through embodied cognition and collaborative negotiation (Hirsh-Pasek et al., 2015), while modern digital games are lauded for enabling dynamic scaffolding and complex systems thinking (Mayer, 2019). However, empirical evidence remains inconclusive, with meta-analyses showing comparable CT gains for both formats (traditional: d = 0.41; modern: d = 0.38; Mao et al., 2022).

Recent studies in developing contexts reinforce this ambiguity. (Almulla, 2023) found that critical thinking and creativity significantly mediate the relationship between 21st-century skills and academic performance among university students in Saudi Arabia, emphasizing the role of smart classroom environments and peer engagement in fostering CT. Meanwhile, (Sun et al., 2023) conducted a systematic review of intelligent game-based learning environments and highlighted that game-based features such as incentives, personalized agents, and navigation significantly influence student engagement and learning outcomes across various educational levels, including in Southeast Asia.

Critical gaps undermine the existing evidence base in this field. First, a substantial majority of studies concentrate on adolescent populations, overlooking the neurodevelopmentally sensitive window of 9-10 years of age (Grades 4-5), a significant limitation recently highlighted in international educational reports (OECD, 2019). Second, persistent methodological shortcomings, particularly regarding inadequate control for order effects and insufficient counterbalancing procedures, compromise the generalizability of findings (Zosh et al., 2018). Existing research also tends to oversimplify game modalities without accounting for design heterogeneity that differentially influences learning outcomes. Third, current critical thinking assessments frequently demonstrate developmental misalignment with younger age groups, thereby reducing measurement validity. Finally, theoretical ambiguity remains unresolved: it remains uncertain whether observed benefits stem from platform-specific characteristics or from shared pedagogical elements such as problem complexity and iterative failure cycles.

This study addresses these gaps through a methodologically rigorous, counterbalanced design with Grade 4 students (N = 54). Core mechanics (rule complexity, challenge duration) were standardized across a traditional game (Catur Jawa) and its modern counterpart. A developmentally adapted critical thinking test ensured measurement validity, while explicitly testing the equivalence hypothesis: that learning outcomes depend more on pedagogical design than delivery medium.

The primary novelty of this research lies in its direct and controlled comparison of traditional and modern game modalities built upon a standardized pedagogical foundation, specifically targeting an understudied age group. This methodological approach enables us to transcend platform-centric debates and distinctly isolate the impact of pedagogical design elements, rather than the medium itself, as the determining factor in fostering critical thinking.

The findings challenge prevailing platform-centric narratives by demonstrating that game modality alone does not significantly influence critical thinking outcomes. Instead, pedagogical design elements, particularly problem complexity, scaffolding mechanisms, and engagement structures, emerge as the critical catalysts for cognitive development. This evidence necessitates a theoretical reorientation from technological determinism toward design-based frameworks in game-based learning research.

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METHODS

This study adopted a counterbalanced 2×2 experimental design to investigate the effects of game type and intervention order on students' critical thinking skills. The design incorporated two main factors: the type of game, which served as a within-subject factor (traditional vs. modern), and the order of intervention, which functioned as a between-subject factor. The research was conducted at Sekolah Dasar Negeri II Siwalankerto, Surabaya, over the course of May and June 2025.

The target population consisted of Indonesian elementary school students aged 9 to 10 years, specifically those enrolled in fourth grade. The participants consist of two classes (4A and 4B). Each class has 27 people. The total participants is 54 students. Inclusion criteria required participants to be within the specified age range, have no documented cognitive impairments, and obtain consent for participation from school authorities and parents.

The research procedure began with the formal approval from the school principal. Both 4A and 4B were appointed by the school authorities. Once the administrative requirements were fulfilled, the intervention phase was initiated. In the first session, students from Group A (class 4A) engaged in the traditional game, while those in Group B (class 4B) participated in the modern game on the same time. Immediately following these sessions, both groups completed the first post-test designed to assess their critical thinking skills.

To mitigate potential carryover effects between interventions, a 6-day washout period was implemented. After this interval, the second session was conducted, during which the intervention types were switched. Group A experienced the modern game (the identical treatment from the previous group B intervention), and Group B engaged in the traditional game (the identical treatment from the previous group A intervention). Upon completion of the second session, both groups again undertook the second post-test.

Each intervention session was structured to last 2x45 minutes, ensuring consistency in exposure time across conditions. The data collected from both post-tests were subsequently pooled and analyzed to evaluate the influence of game type and intervention order on students' critical thinking performance.

Critical thinking skills were assessed as the primary data collection technique using a contextually adapted version of the Cornell Class Reasoning Test, Form X. The adaptation process involved item selection and linguistic modification. Six items were selected based on construct validity and their alignment with the cognitive development stage of 9–10-year-old children. Linguistic adjustments included simplifying sentence structures and contextualizing scenarios to enhance comprehension. The test was administered in written form under controlled conditions after each game session.

The instrument used were adapted from the widely used and tested source (Cornell Class Reasoning Test) for many years. This is also reflected in the good reliability test results. From the sample obtained, the Cronbach's alpha coefficient of 0.89 demonstrated strong psychometric properties. The suitability of the application of the instrument was confirmed by the internal consistency of the test for this specific population.

The traditional game used is a modified traditional Indonesian game, named Catur Jawa. The Catur Jawa itself is not a variation of the widely known chess game. The strategy-based game played on a special chessboard increases in complexity. Improvement (modification) is carried out by differentiating chess pieces into two types, with different variations of movements or steps. Meanwhile, the original Catur Jawa has only one type of chess piece and a movement pattern. The challenge of determining the movements or steps of pawns with these variations trains students to think critically, so that their strategy can penetrate the opponent's area.

Meanwhile, the modern game used is called Modern Market. This game is a modification of rally games with posts containing questions (with various levels of difficulty), as well as activities or challenges around the concept of modern markets. Modifications are also carried out by replacing the player's physical presence with a robotic car, which has been programmed to move with variations of forward (two steps), backward (one step), turning right, and turning left. This robotic car is placed in a game arena in the form of a

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line/route map measuring 2x2 meters, which has branches. Challenges to determine route selection strategies based on distance, along with the number and level of difficulty of challenges, are designed to train students to think critically.

Data were analyzed using Repeated Measures ANOVA in a statistical calculation software, following verification of parametric assumptions. This statistical approach allowed for the examination of within-subject and between-subject effects, providing insights into the impact of game type and intervention order on critical thinking performance. This study received ethical approval for implementation from the school. Informed consent was obtained from the parents of all participants through a formal permission letter granted by Mrs. Dwi Kirana Moehani, the Principal of Sekolah Dasar Negeri II Siwalankerto.

RESULT AND DISCUSSION

The critical thinking scores for both game types across counterbalanced groups are summarized in Table 1. Traditional games (M = 3.20, SD = 1.24) demonstrated marginally higher mean scores compared to modern games (M = 2.83, SD = 1.45). Group A (traditional-first sequence) scored higher in both conditions than Group B (modern-first sequence).

Table 1. Descriptive Statistics for Critical Thinking Scores

Group	Game Type	*n*	Mean	SD	95% CI
Group A	Traditional	27	3.48	1.20	[3.00, 3.96]
	Modern	27	3.07	1.50	[2.49, 3.65]
Group B	Modern	27	2.59	1.39	[2.04, 3.14]
	Traditional	27	2.93	1.27	[2.43, 3.43]
Total	Traditional	54	3.20	1.24	[2.86, 3.54]
	Modern	54	2.83	1.45	[2.43, 3.23]

Prior to conducting inferential analyses, assumption checks were performed. The Shapiro–Wilk test confirmed the normality of the data ($p > .05$), while Mauchly's test indicated that the assumption of sphericity was met ($p = .214$). Levene's test for homogeneity of variance was also nonsignificant ($p = .561$), supporting the suitability of the repeated measures ANOVA.

Table 2. Results of 2×2 Repeated Measures ANOVA for Critical Thinking Scores

Source	Type III SS	df	MS	F	p
Within-Subject Effects					
Game Type	4.892	1	4.892	3.13	.083
Game Type × Sequence	0.047	1	0.047	0.03	.860
Error (Game Type)	81.338	52	1.564		
Between-Subjects Effects					
Sequence Order	10.815	1	10.815	2.85	.097
Error	197.259	52	3.793		

A 2×2 repeated measures ANOVA was conducted to examine the effects of game type (traditional vs. modern) and sequence order (Group A vs. Group B) on critical thinking scores. The analysis revealed a nonsignificant main effect of game type, $F(1, 52) = 3.13$, $p = .083$, $\eta^2_p = .057$, indicating that the difference in mean scores between traditional and modern games was not statistically significant. Similarly, the main effect of sequence order was nonsignificant, $F(1, 52) = 2.85$, $p = .097$, $\eta^2_p = .052$, suggesting that the order in which participants experienced the game types did not significantly affect their performance. The interaction effect

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between game type and sequence order was also nonsignificant, $F(1, 52) = 0.03$, $p = .860$, $\eta^2_p = .001$, indicating no combined influence of these variables on critical thinking outcomes. The present study investigated the differential impact of traditional and modern games on the development of critical thinking skills in fourth-grade students. The findings revealed no statistically significant differences between the two game formats, prompting a nuanced discussion that integrates contemporary theoretical frameworks, contrasts with recent literature, and acknowledges the study's limitations and contributions.

This study supports Richard E. Clark's media equivalence theory, which states that media do not directly affect learning outcomes. Instead, the effectiveness of media depends on the instructional methods used within them. When traditional and modern games use effective instructional design, they achieve similar learning results, regardless of the medium. Clark (2012) described media as "vehicles" for delivering instruction, with learning outcomes driven by the instructional strategies. Recent meta-analyses confirm that different media formats yield similar educational results when instructional design remains consistent.

Research over the past decade consistently supports this view. A meta-analysis by Tamim et al., (2011) reviewing four decades of studies on technology in education, found that positive learning effects stem from instructional strategies, not the media itself. This aligns with Clark's argument that pedagogy, not technology, drives learning. Similarly, Schmid et al., (2014) conducted a systematic review of technology use in post-secondary education and found no significant differences in learning outcomes across media when instructional methods were similar.

Those findings are consistent with An's (2020) study showing that the development of learning and instruction media was not automatically applied practically by teachers. This condition occurs due to some issues, such as additional costs, teachers' resistance to change, lack of guidelines for using the media, and systemic barriers like organizational structures, and so on. These factors contribute to the minimal impact of media integrated into instructional practices in the learning process, especially the newly developed media.

The principle of media equivalence extends directly to game-based learning. Research indicates that the educational efficacy of a game is determined by its embedded instructional design rather than its technological sophistication. Clark et al., (2016), in a review of digital games for learning, was emphasized that game features must align with desired learning outcomes and include proven instructional strategies to be effective. This is further supported by Wouters & van Oostendorp (2017), whose meta-analytic review identified instructional support (e.g., feedback, modeling) as a critical moderator of learning in game-based environments, often more impactful than the game's format.

Importantly, studies that directly compare digital and non-digital (or traditional) games have provided evidence supporting the theory of media equivalence. Hainey et al., (2016) found that both digital and non-digital games were effective for improving learning in programming, with no inherent superiority of one medium over the other. This study focuses on the context of primary education, targeting younger learners to assess the impact of game-based learning interventions. Specifically, this research investigates the use of games to support programming education. The field was characterized by abstract concepts and significant cognitive demands, including logical reasoning and algorithmic thinking.

Research by Lin & Cheng (2022) on mathematics education also demonstrated the same inclination. A well-designed board game could be as effective as a digital equivalent in promoting conceptual understanding and procedural fluency, provided both implemented similar game mechanics and pedagogical structures. A prevailing assumption in the digital era is that digital games are inherently more engaging, interactive, and therefore more effective for learning than traditional formats such as board games. This belief has been widely echoed in both popular discourse and educational practice. However, the findings of the present study challenge this notion by demonstrating that well-designed non-digital games can rival, and in some cases match, the pedagogical effectiveness of sophisticated digital games.

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This insight serves as a powerful reminder that innovation in educational technology should not be conflated with automatic superiority; "new" does not necessarily equate to "better". Rather than framing the debate as a dichotomy between digital and non-digital media, the study emphasizes the central role of instructional design in determining the success of educational games. The key takeaway is that learning outcomes are optimized when both game formats implement similar game mechanics and pedagogical structures. This finding underscores that the medium of delivery is secondary to the quality of design.

On the other hand, several studies have also demonstrated that modern games can be highly effective. These modern games typically incorporate digital programming components within their gameplay mechanics. In the context of a developing country such as Vietnam, the use of modern games with an entrepreneurial theme has been shown to enhance critical thinking skills. Critical thinking is one of the essential components of entrepreneurial competence, particularly in analyzing situations and making decisions (McDonald, 2017).

In addition, there is a study related to the subject of informatics education in Indonesia. Within the context of distance learning, the subject was delivered through a modern game-based digital application. The game application was titled Critical Thin[k]ing Adventure. The implementation of this application demonstrated an improvement in students' critical thinking skills, with a gain score of 0.63, categorized as moderate. In comparison, the control group, which underwent instruction without the application, achieved a gain score of 0.43. This indicates a positive impact of using modern games, although both gain scores fall within the same moderate category (Samin et al., 2022).

In addition to the aforementioned studies conducted outside the elementary school level, there are also research efforts carried out specifically at the elementary level in Indonesia. One such study involved the development of a game-based learning application designed for fifth-grade students, targeting thematic subjects including Indonesian Language, Science, and Arts and Crafts. The game was implemented using an HTML5-based format. The results of the implementation indicated a significant improvement in students' critical thinking skills (Fitriyadi & Wuryandani, 2021).

Although modern educational games appear to be effective in enhancing critical thinking skills, there are more detailed aspects that require careful consideration. Effective game-based learning depends on two key components: game mechanics and pedagogical structure. Game mechanics include the rules, challenges, player interactions, and reward systems that shape the gameplay experience and help maintain learner engagement. Pedagogical structure refers to how educational content, such as conceptual understanding and procedural fluency in mathematics, is integrated into the game. When both components are thoughtfully and effectively designed, they work together to support meaningful learning, regardless of whether the game is delivered in digital or non-digital formats.

When these elements are thoughtfully and equally integrated, both digital and non-digital games can facilitate meaningful learning experiences. This study, therefore, reaffirms that the instructional architecture of a game is the primary determinant of its educational value, rather than the technological sophistication of its medium. Challenges may arise, however, when the use of technology is not supported by the fulfillment of basic cognitive prerequisites. The effective use of technology in learning environments requires a certain level of thinking skills, particularly critical thinking abilities (Szabo et al., 2020). This issue becomes increasingly critical in learning contexts aimed at understanding the operational principles of robotic devices, which inherently involve programming. Such conditions are particularly relevant for the students involved in this study, who had not previously received instruction in coding or robotic programming. However, this challenge is less significant when robotic devices are utilized for their secondary function, namely as analogical or learning tools, as discussed by (Eguchi, 2017) and (Sullivan & Heffernan, 2016).

While some scholars, echoing Kozma's (1994) call for a consideration of media and method interactions, argue that certain media afford unique capabilities, recent syntheses often circle back to the

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primacy of design. Mayer (2019), in his principles of multimedia learning, focuses on how to design instructional messages effectively across different media, implicitly supporting the notion that the core principles of learning transcend the specific medium used. In line with this perspective, meta-analytic findings suggest that the presence of structured guidance, rather than the medium of delivery, is a key determinant of learning efficacy in game-based environments (Zhang et al., 2020). The comparable outcomes observed in this study, in which both games were implemented without differentiated scaffolding, further reinforce the argument that pedagogical design plays a more critical role than technological sophistication in determining learning effectiveness. This research makes a significant contribution to the contemporary understanding of educational technology effectiveness, providing empirical evidence that the impact of a learning tool is not dictated by its technological sophistication but by its alignment with sound pedagogical design (Mayer, 2020).

Taken together, these findings reinforce the central argument of Mayer's Cognitive Theory of Multimedia Learning. It posits that learning effectiveness is primarily driven by the design of instructional materials that manage cognitive load and foster meaningful engagement, rather than by the technological medium itself. The comparable outcomes observed across different game formats in this study suggest that, in the absence of differentiated scaffolding. Thus, the medium options alone do not automatically influence learning gains significantly.

These results affirm that the effectiveness of game-based learning is not primarily determined by the technological platform. The quality of its pedagogical design is the main determining factor. Elements such as cognitive load management, task structuring, and the presence or absence of instructional scaffolding play a more decisive role in shaping learning outcomes. Therefore, future research should focus on refining the pedagogical strategies embedded within educational games to ensure their impact remains consistent across different formats and delivery modes. Additionally, research can be expanded by incorporating variables related to computational thinking skills, which are closely associated with the use of technologies such as robotic devices in educational games, as explored in the study by Altıok & Ucgul (2024).

CONCLUSION

This study examined the comparative impact of traditional and modern games on the development of critical thinking skills among fourth-grade students. The results revealed no statistically significant difference in effectiveness between the two game types. This finding challenges the commonly held assumption that digital games are inherently superior in promoting cognitive development due to their technological features. The main contribution of this research is the empirical evidence that the educational value of a game is not determined by its technological format. Instead, it is shaped by the quality of its instructional design and pedagogical structure. Well-designed games, regardless of whether they are digital or traditional, can support meaningful learning when they incorporate clear rules, engaging mechanics, and appropriate cognitive load management. This study highlights that traditional games, when thoughtfully constructed, can be just as effective as modern digital games in fostering critical thinking. The novelty of this research lies in its focus on primary education, a context where digital tools are often prioritized. By demonstrating that traditional games can yield comparable learning outcomes, the study provides counterevidence to the dominant narrative favoring digital media. This has practical implications for educators, curriculum designers, and educational game developers. Rather than investing heavily in technological platforms, stakeholders should concentrate on strengthening the pedagogical foundations of the games they implement in classrooms. Based on these findings, the study recommends a shift in research and practice from a medium-centric approach to a design-centric paradigm. Future investigations should aim to isolate and examine specific instructional design features, such as scaffolding strategies, feedback mechanisms, and task complexity, that contribute to learning effectiveness across various game formats.

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