Development Of Educational Interactive Game Media Based On Child-Friendly Learning In Mathematic Content To Improve Critical Thinking Understanding

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Abstract : This research and development (R&D) aimed to test the feasibility (validity and practicality) and effectiveness of the Child-Friendly Learning-based Interactive Game Educational Media in improving fifth-grade elementary school students' understanding of mathematic The main problem identified was the lack of interactive use of conventional media, resulting in passive, unenthusiastic students, and difficulties in understanding the mathematic material. The development model used was ADDIE (Analysis, Design, Development, Implementation, Evaluation), and the study was conducted at Sambiroto Elementary School and Mojosari 2 Elementary School. The results showed that the EDUMIG media had excellent validity (Media Experts 94%, Material Experts 91.5%) and very high practicality (Teachers 97.3%, Students 100%). This media proved significantly effective, as evidenced by the T-Test results of 0.000 (<0.05), indicating a significant difference in the average scores between the two classes. The increased effectiveness was reinforced by the experimental class' N-Gain value of 0.659 (moderate category), significantly higher than the control class's (0.257, low category). Thus, Educational Interactive Game Media has successfully become a valid, practical, and effective innovative solution for increasing the motivation, engagement, and conceptual understanding of mathematic students**.**

Keyword : Educational Interactive Game Media, Child-Friendly Learning, Critical thinking Understanding, Mathematic.

Introduction

Indonesia is actively pursuing efforts to improve its education quality to cultivate a superior and skilled future generation, notably through the transition to the Merdeka Curriculum, which prioritizes relevant, student-centered instruction (Kemendikbudristek, 2022).Within this pedagogical shift, Mathematics retains its fundamental status, valued not just as a tool for computation but crucially as a vehicle for developing logical and systematic thinking skills. This essential 21st-century ability is formally referred to as Critical Thinking Understanding (CTU) (Zakarina et al., 2024). Aligning with modern educational demands, CTU is a crucial foundation that enables students to analyze challenges, make evidence-based judgments, and solve complex problems (Buchori et al., 2025). For Elementary School students, whose stage of development necessitates concrete thinking, instruction must be holistic, engaging, and relevant. Consequently, contemporary learning design must integrate a Child-

Friendly Learning (CFL) approach, which focuses on establishing a learning environment that is safe, supportive, inclusive, and conducive to students' full psychological and emotional growth. This student-centric model has been consistently shown to foster an enjoyable atmosphere and enhance student motivation (Herawati, 2024)

Despite the recognized importance of both mathematical competency and the CFL approach, practical implementation at the grassroots level exhibits a significant gap. Observations and interviews conducted at SDN Sambiroto in Rembang Regency revealed a core problem in mathematics instruction: the minimal use of learning media and a predominant reliance by teachers on didactic, one-way lecture methods. This situation leads directly to student boredom, low engagement, and passive learning, a challenge compounded by the underutilization of the school's existing digital assets, such as Chromebooks. The consequence of this environment is clearly visible in student performance: the average score for fifth-grade students in the 2024/2025 Semester Final Assessment (PAS) was 70, with a concerning 78% (18 students) failing to meet the Minimum Completeness Criterion (KKM). This data points to a serious shortfall in students' conceptual understanding of mathematics and their critical thinking skills. To remedy this, a strategic alternative is urgently required, specifically the development of interactive digital learning media that is engaging, enjoyable, and leverages modern technology to directly address these instructional shortcomings.

Research into interactive media development offers a strong precedent in education, with numerous studies consistently affirming that multimedia-based interactive learning tools meet the necessary criteria for validity, practicality, and effectiveness in boosting learning outcomes (Safitri et al., 2025).Furthermore, innovative technologies like Augmented Reality (AR) Educational Games have demonstrated substantial potential by maximally increasing student motivation and achievement, particularly for abstract mathematical concepts like fractions (Buchori et al., 2025). This evidence supports the notion that interactive media can create a self-exploratory learning environment, which is a key precondition for cultivating Critical Thinking Understanding. However, a review of existing literature reveals that few studies have explicitly integrated the triad of interactive digital media development, a focus on mathematical content for Critical Thinking Understanding, and the Child-Friendly Learning (CFL) pedagogical approach. Current media, while technologically effective, often falls short of fully accommodating the emotional and psychological aspects of elementary students as mandated by the CFL framework(Slamet, 2025).

The Novelty of this research significantly distinguishes it from previous work through its Explicit Three-Dimensional Integration. While earlier studies have tended to address media effectiveness, critical thinking enhancement, or CFL implementation

in isolation, the core innovation here is the deliberate integration of Interactive Digital Media Development with the Child-Friendly Learning framework as the guiding pedagogical strategy, all centered on improving Mathematical Critical Thinking Understanding. This holistic integration is designed to produce media that is not only efficient technologically but also deeply engaging and psychologically supportive. Furthermore, this study offers a Contextual Solution to the immediate, critical gap identified at SDN Sambiroto, where poor results (78% below KKM) stem from lecture-dominant teaching and underutilized digital resources. The innovation lies in designing a specific media solution that actively disrupts the lecture method and fully optimizes the school's existing hardware (Chromebooks/Projectors), a practical challenge not fully resolved by prior research.

Based on these critical gaps, two main research problems are formulated: First, how can the validity, practicality, and effectiveness of the developed interactive digital learning media, which is based on Child-Friendly Learning principles, be measured in the context of improving the Mathematical Critical Thinking Understanding of fifth-grade students at SDN Sambiroto? Second, to what extent can the implementation of the Child-Friendly Learning-based interactive digital media enhance both the cognitive learning outcomes and the Mathematical Critical Thinking Understanding of fifth-grade students at SDN Sambiroto? As a preliminary assumption, the hypothesis H1 posits that there will be a significant increase in the cognitive learning outcomes and Mathematical Critical Thinking Understanding of fifth-grade students at SDN Sambiroto following the implementation of the Child-Friendly Learning-based interactive digital learning media. Aligned with the national agenda for educational improvement, the study ultimately aims to: 1) Develop and validate the practicality of the Child-Friendly Learning-based interactive digital learning media for fifth-grade Mathematics, and 2) Analyze the effectiveness of implementing this developed media in enhancing the cognitive learning outcomes and Mathematical Critical Thinking Understanding of the fifth-grade students at SDN Sambiroto.

Method

This study employs a Research and Development (R&D) framework utilizing the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). To ascertain the product's effectiveness, the Implementation phase incorporates a modified quasi-experimental design known as the Pretest-Posttest Control Group Design(Sugiyono, 2020). The research subjects comprise 61 fifth-grade elementary students, purposefully divided into two groups: an experimental group (31 students from SDN Sambiroto) and a control group (30 students from SDN 2 Mojosari). The primary instruments employed are written tests (*pre-test* and *post-test*) to measure

cognitive learning outcomes and Critical Thinking Understanding, expert validation questionnaires (covering media, material, and learning aspects) to determine theoretical feasibility, and teacher/student response questionnaires to assess practical utility. The data collection procedure strictly follows the sequential steps of the ADDIE cycle, commencing with needs analysis, media design, development, expert validation, and culminating in the field-testing on the research subjects. Finally, data analysis involves both qualitative techniques (narrative descriptive analysis for expert feedback) and quantitative methods, where the core test for effectiveness is the T-test, used to compare the significance of the difference in mean learning scores between the experimental and control groups following the EDUMIG media implementation(Murti & Winarti, 2023).

Results and Discussion

The Research and Development study employed the ADDIE model(Rahayu et al., 2024), beginning with the analysis stage. This stage involved assessing the learning needs of students at SD N Sambiroto in mathematics. It was found that conventional teaching methods struggled to deliver complex math content in an engaging manner that aligns with *Child-Friendly Learning* principles. Crucially, the school currently lacks dedicated, current interactive media explicitly designed to cultivate students' critical thinking understanding. Furthermore, both students and teachers are unfamiliar with integrating educational game media for this specific learning objective. The analysis also highlighted the need to upgrade supporting school facilities to accommodate the application of the *Educational Interactive Game*. These findings established the foundational necessity for developing media that integrates *Child-Friendly Learning* principles to effectively enhance students' critical thinking in mathematics.

The foundation of this development research was the Analysis Stage of the ADDIE model, which aimed to pinpoint the specific mathematical learning needs at SD N Sambiroto. The results of this initial analysis highlighted an urgent requirement for innovative approaches to teach challenging mathematics content. Traditional teaching methods were found to be insufficient in fostering an engaging learning environment aligned with the principles of Child-Friendly Learning, a vital element for elementary school students. A critical gap identified was the absence of a contemporary, interactive medium specifically designed to enhance students' critical thinking skills within mathematics content. This finding was further substantiated by the fact that both students and teachers lacked familiarity with utilizing educational game media to achieve critical thinking objectives. Additionally, limitations in adequate supporting facilities posed a challenge for implementing an Educational Interactive Game. Consequently, these findings established the fundamental rationale for developing a medium that effectively integrates Child-Friendly Learning principles to sharpen students' critical thinking abilities.

Table 1. Recapitulation of the Validity Results of the Educational Interactive Game Product

Expert	Average Score	Persentase	Category
Media	95	95%	Very Valid
Material	92.5	93%	Very Valid
Overal Average	93.75	94%	Very Valid

Following the Design and Development stages, the created medium underwent feasibility testing. The validity test for the Educational Interactive Game demonstrated that the developed medium met high-feasibility criteria. Based on assessments by material experts and media specialists, the medium achieved an average validity score of 93.75%, classifying it as "Very Valid." This score confirms that both the mathematical content and the interactive design are appropriate for Child-Friendly Learning principles and the intended learning objectives. Detailed validation results are presented in Table 1.

Table 2. Practicality Test Results

Respondenents	Persentase	Category
Teacher Respondenents	97.3%	Very Practical
Student Respondenents	100%	Very Practical
Overal Average	98.65 %	Very Practical

Furthermore, the practicality testing, derived from teacher and student response questionnaires, yielded an average score of 98.65%, falling into the "Very Practical" category. This outcome signifies that the interactive game medium is user-friendly, efficient, and can be effectively integrated into classroom learning. The practicality results are summarized in Table 2.

Table 3. Results of Improvement (N-Gain) in Understanding Critical Thinking in Mathematics

Class	Average Pretest Score	Average post-test Score	Improvement (N- Gain)	N-Gain Category
Experiment (with EDUMEDIG)	50.37	85.2	0.710	High
Control (without EDUMEDIG)	48.67	61.87	0.257	Low

To assess the medium's effectiveness in boosting students' critical thinking skills, a comparative analysis was conducted between the pre-test and post-test scores of the experimental group. The calculated N-Gain scores revealed a significant improvement in students' critical thinking ability after using the interactive game medium. The average N-Gain score obtained was 0.67, which is categorized as moderate. This increase confirms that the Educational Interactive Game is an effective instructional tool for honing students' critical thinking skills in mathematics content. Statistical data regarding this improvement is summarized in Table 3, and the visualization of the enhancement in students' critical thinking understanding is clearly presented in Figure 1 .

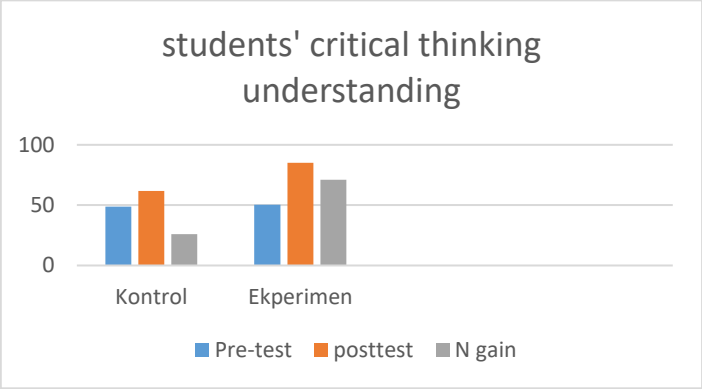

Figure 1. Comparison of N-Gain Values for Improving Critical Thinking Understanding

The mathematical content, packaged as engaging and interactive challenges, successfully established a safe and stimulating learning environment that aligns perfectly with the student-centered principles of Child-Friendly Learning. Students' active involvement in solving the mathematical problems presented through the game directly triggers the cognitive activation essential for critical thinking. This includes developing skills such as analyzing complex issues, evaluating diverse information, and logically determining appropriate solutions. This finding strongly supports established theories suggesting that core game elements—namely challenge, immediate feedback, and high interactivity—intrinsically motivate students to engage in higher-order reasoning, which constitutes the very essence of critical thinking comprehension.

his research strengthens the findings of previous studies, such as those demonstrated by Lowther, (Nurhikmah & , Rustiani S, 2024)and similar research by (Tri Antika Indah Listiana, Sri Suneki, Joko Suliyanto, 2023) which also show the positive impact of using interactive media or educational games on student learning

outcomes. However, the unique advantage and contribution of this study lie in its explicit integration of primary-level mathematics content, the strict implementation of the Child-Friendly Learning approach, and a primary focus on measuring the enhancement of critical thinking comprehension—an aspect rarely comprehensively highlighted within a single media development study. The developed Educational Interactive Game offers a learning alternative that is more relevant, innovative, and aligned with the psychological characteristics of SD N Sambiroto students. With the high verified validity (Media Experts 94%, Material Experts 91.5%) practicality (Teachers 97.3%, Students 100%), and proven effectiveness (N-Gain 0.67 in the moderate category) of this medium, the findings of this research serve as a valuable reference for curriculum innovation and mathematics learning resources in Elementary Schools that are oriented toward developing 21st-century skills, particularly critical thinking ability.

Conclusion

This R&D study successfully developed and tested the Educational Interactive Game (EDUMEDIG), a CFL-based digital medium. The product demonstrated high feasibility, achieving 92.75% Validity and 98.65% Practicality. The core finding supports the hypothesis H_1, confirming that the EDUMEDIG implementation caused a significant increase in fifth-grade students' Mathematical Critical Thinking Understanding (CTU). This effectiveness is evidenced by the high N-Gain score of 0.710 (High category), attributed to the strategic integration of mathematics content, CFL principles, and Game-Based Learning elements. Future research should focus on long-term studies regarding knowledge retention and exploring development into an Augmented Reality (AR) format.

References

Alika, O., Sulianto, J., & Sutono, A. (2025). Developing CEKATAN: A Crossword Puzzle-Based Learning Media to Enhance Literacy Skills in Grade 2 Elementary School Students. *Jurnal Kependidikan: Jurnal Hasil Penelitian dan Kajian Kepustakaan di Bidang Pendidikan, Pengajaran, dan Pembelajaran*, *11*(3), 1250-1258.

Buchori, A., Cahya, P. Z., & Wardani, T. I. (2025). *Design and Development of an Interactive Scouting Educational Game Using the MDLC Approach*. *7*(2), 1–8.

Herawati, N. I. (2024). *Upaya Mewujudkan Sekolah Inkusif : Sekolah Ramah Anak Dalam Implementasi Kurikulum Merdeka di Sekolah Dasar(Efforts to Realize Inclusive Schools: Child-Friendly Schools in the Implementation of the Independent Curriculum in Elementary Schools)*. *2*(3), 82–94.

Kemendikbudristek. (2022). Peraturan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 13 Tahun 2022 tentang Perubahan Atas Peraturan Menteri

Pendidikan dan Kebudayaan Nomor 22 Tahun 2020 tentang Rencana Strategis Kementrian Pendidikan dan Kebudayaan tahun 2020-2024. *Jdih.Kemendikbud.Go.Id*, 1–242.

Murti, R. D. K., & Winarti, E. (2023). Desain Pembelajaran Ramah Anak di Sekolah Dasar (Suatu Kajian Teori)*(Child-Friendly Learning Design in Elementary Schools (A Theoretical Study))*. *PEDADIDAKTIKA: Jurnal Ilmiah Pendidikan Guru Sekolah Dasar*, *10*(3), 506–519. https://doi.org/10.17509/pedadidaktika.v10i3.64419

Nurhikmah, & , Rustiani S, N. (2024). *Literature Review : Media Game Edukasi Interaktif dalam Pembelajaran Matematika(Literature Review: Interactive Educational Game Media in Mathematics Learning)*. *5*(4), 4382–4390.

Rahayu, D. A., Dirgantoro, A., Purnamasari, N. L., & Putra, A. A. P. E. (2024). *Development of Microlearning Based on Project Citizenship in Citizenship Learning to Improve Students ' Civic Disposition*. *December*, 8–14.

Safitri, D., Manik, W., Yawai, T., & Khairunnisa, N. (2025). Efektivitas Media Pembelajaran Interaktif Berbasis Digital Dalam Pendidikan: Tinjauan Sistematis Lintas Disiplin Ilmu*(The Effectiveness of Digital-Based Interactive Learning Media in Education: A Systematic Cross-Disciplinary Review*). *Proceeding International Seminar on Islamic Studies*, *6*(1), 1714–1721.

Slamet, S. Y. (2025). *The Effectiveness of Interactive Learning Media in Improving Students ' Understanding of the Food Chain Concept in Elementary Schools*. *11*(6), 340–348. https://doi.org/10.29303/jppipa.v11i6.11099

Sugiharti, A., Sulianto, J., & Buchori, A. (2025). Development of an integrated learning device Wordwall application: An elementary school student's science literacy skills. *Indonesian Journal of Educational Development (IJED)*, *6*(3), 954-970.

Sugiyono. (2020). *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*.

Tri Antika Indah Listiana, Sri Suneki, Joko Suliyanto, L. P. (2023). *ANALISIS DALAM MENERAPKAN MEDIA INTERAKTIF WORDWALL PADA PEMBELAJARAN TEMATIK DI KELAS III SDN WONOTINGAL 1(ANALYSIS OF APPLYING INTERACTIVE WORDWALL MEDIA IN THEMATIC LEARNING IN GRADE III OF SDN WONOTINGAL 1.)*. *09*, 5224–5233.

Zakarina, U., Ramadya, A. D., Sudai, R., & Pattipeillohi, A. (2024). Integrasi Mata Pelajaran Ipa Dan Ips Dalam Kurikulum Merdeka Dalam Upaya Penguatan Literasi Sains Dan Sosial Di Sekolah Dasar *(Integration of Science and Social Sciences Subjects in the Independent Curriculum in an Effort to Strengthen Science and Social Literacy in Elementary Schools*). *Damhil Education Journal*, *4*(1), 50. https://doi.org/10.37905/dej.v4i1.2487