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EFFECTIVENESS OF PBL-BASED TORMA CODE INTERACTIVE MEDIA FOR ENHANCING ELEMENTARY STUDENTS' CRITICAL THINKING AND PROBLEM-SOLVING SKILLS: A RESEARCH AND DEVELOPMENT STUDY

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ABSTRACT
This study developed and evaluated the Torma Code interactive media, a PBL-based innovation that integrates physical models with barcode-activated digital content to enhance fourth-grade students' critical thinking skills in IPAS learning on the topic of the visual sense. Using the ADDIE development model, the research involved expert validation, practicality testing, and a pretest–posttest effectiveness design. The media, teaching module, and assessment instruments were classified as highly valid (≥90%), indicating strong alignment between content accuracy, linguistic appropriateness, and instructional coherence. Practicality testing showed consistently positive responses from teachers (92.5%) and students (93.6%), demonstrating that the media are accessible, engaging, and pedagogically useful. The paired-sample t-test confirmed a statistically significant improvement in students' critical thinking performance ($p < 0,05$), supported by a moderate N-Gain score (0,55). The novelty of this study lies in its multimodal design that connects concrete anatomical models with problem-based digital exploration, offering an alternative to fully digital media commonly used in previous studies. These results indicate that the Torma Code media effectively facilitates contextual, collaborative, and student-centered learning aligned with the Merdeka Belajar curriculum. The product is therefore feasible for wider adoption in elementary schools to support the Merdeka Belajar curriculum and strengthen students' scientific literacy.

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INTRODUCTIONS

The rapid advancement of science and technology in the era of globalization has significantly influenced various aspects of life, including education. Twenty-first century education requires students to acquire not only cognitive abilities but also higher-order thinking skills and adaptability to continuous change (Relitawati et al., 2024). In this context, the concept of 21st Century Skills commonly known as the 4Cs: Critical Thinking, Collaboration, Communication, and Creativity serves as a fundamental framework for preparing young generations to face future challenges with critical, creative, and innovative mindsets. Among these skills, critical thinking is particularly crucial. Davidi et al. (2021) emphasize the need for integrating critical thinking into the learning process starting from elementary school. Ennis and Glaser describe critical thinking as a reflective, logical, and objective process for making well-grounded decisions (Syafitri et al.,2021; Novandi et al., 2025). Firdausi et al. (2021) further explain that critical thinking is closely related to one's ability to solve complex real-life problems.

Despite existing initiatives, empirical studies consistently show that elementary students' critical thinking performance remains low due to the dominance of teacher-centered instruction and limited use of interactive media. Amalia et al. (2021) highlight that students demonstrate limited critical thinking abilities in science learning due to teacher-centered instruction and the lack of appropriate learning media. Similar conditions were found at SDN Watupecah, where preliminary assessments indicated low critical thinking skills in the topic of visual senses. Teacher interviews confirmed that learning still relied heavily on traditional lecturing methods, resulting in low student engagement. According to Hayati and Setiawan (2022), such challenges stem from teachers' limited readiness in designing instruction, minimal use of interactive media, and the underutilization of models that foster scientific thinking.

Theoretically, constructivism provides a strong foundation for addressing these gaps, as it views learning as an active process in which learners construct knowledge through experience and interaction with their environment. Students build meaningful understanding by connecting new information with prior knowledge (Sulthon, Nuriman, & Handayani, 2022). Recent studies support the effectiveness of constructivist principles in modern instruction. Cahyaningsih and Nahdi (2025) found that interactive e-modules based on Problem Based Learning (PBL) enhance analytical and reasoning skills. Mulyawati et al. (2024) demonstrated that constructivism-based digital modules significantly improve students' critical thinking and communication skills. Likewise, Abdulah, Mustadi, and Fitriani (2024) reported that interactive multimedia using constructivist approaches fosters creativity and higher-order thinking abilities.

Interactive learning media play a strategic role in supporting these processes. Putri et al. (2022) explain that interactive media facilitates two-way communication and creates an engaging learning experience. Furthermore, such media attract students' attention, reduce excessive verbal explanation, and enrich learning through audio visual text integration (Roosita et al., 2022). In the context of science learning, interactive media enhance conceptual understanding through multisensory and concrete learning experiences (Indartiwi et al., 2022). Yuanta et al. (2024) additionally emphasize that interactive media strengthen critical thinking, collaboration, and creativity.

A promising innovation that addresses these instructional gaps is the Torma Code interactive media, which integrates physical learning objects with barcode-linked digital content to support multimodal learning experiences, which combines physical and digital elements through an anatomical eye model equipped with barcodes containing videos, images, and digital learning links. This media is designed to help students understand the topic of visual senses, particularly the impact of gadget use on eye health. Through observation and scanning activities, students are encouraged to think critically and analyze real-life phenomena. This aligns with the principles of PBL, wherein students actively explore authentic problems through reflective and investigative processes (Purnama et al., 2024).

Problem Based Learning itself is highly relevant to the demands of 21st-century education and the Merdeka Curriculum, as it emphasizes contextual, analytical, and collaborative learning (Relitawati et al., 2024). Purnama et al. (2024) outline the steps of PBL, which include problem orientation, student organization, guided investigation, solution presentation, and process analysis. Studies by Amalia et al. (2021) and Davidi et al. (2021) confirm that PBL significantly improves elementary students' critical thinking skills.

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Psychologically, the use of such media and models aligns with Piaget's cognitive development theory, which states that elementary school students are at the concrete operational stage capable of logical thinking when dealing with tangible objects and direct experiences (Marinda, 2020; Kusmiati et al., 2024). Therefore, problem-based learning supported by interactive media is highly appropriate for developing students' critical thinking skills (Firdausi et al., 2021).

However, no previous studies have examined the integration of physical digital hybrid media such as Torma Code within a Problem-Based Learning framework to enhance critical thinking in elementary IPAS learning. This explicit gap highlights the need for innovative instructional solutions that merge multimodal interactivity with authentic problem exploration.

Based on these considerations, this study aims to analyze the effectiveness of PBL-Based Torma Code Interactive Media in enhancing elementary students' critical thinking and problem-solving skills. The novelty of this research lies in its integration of physical–digital hybrid media with PBL to promote multimodal inquiry, authentic problem analysis, and higher-order thinking an approach that has not been empirically explored in previous IPAS studies.

METHOD

This study employed a Research and Development (R&D) method aimed at producing innovative and effective learning media tailored to elementary school needs. R&D is defined as a systematic effort to design and validate educational products that can be practically implemented in real classroom settings (Okpatrioka, 2023; Rangkuti, 2016). The ADDIE model was used as the development framework because it provides a structured and iterative sequence Analysis, Design, Development, Implementation, and Evaluation that ensures the learning product is theoretically sound, practical, and effective (Slamet, 2022). Ethical procedures including informed consent, voluntary participation, and confidentiality were maintained throughout data collection.

The analysis stage identified instructional challenges through observations, teacher interviews, and a critical thinking pretest. Findings revealed that science learning on the topic of visual senses relied heavily on lectures, resulting in low conceptual understanding and limited critical thinking performance. The design stage conceptualized the Torma Code interactive media integrating barcode-linked digital content, an anatomical eye model, and smartphone simulations aligned with elementary students' visual exploratory learning tendencies. Research instruments including expert validation sheets, practicality observation sheets, and critical thinking tests were designed according to theoretical indicators from Harahap & Siregar (2018) and Ramadhani et al. (2022). Long descriptive explanations were streamlined to focus on essential methodological steps only.

The development stage produced a functional prototype, which was validated by two media and learning experts from UniversitY of PGRI Semarang using a Likert-scale instrument adapted from Akbar in Slamet (2022). The implementation stage involved limited class trials in Grade 4 at SDN Watupecah and SDN Sumurpule to measure practicality and effectiveness through observation, pretests, and posttests. Purposive sampling was used because R&D studies require participants who directly match the characteristics of the target users namely Grade 4 students studying the visual senses topic and teachers implementing PBL ensuring alignment between product design and instructional needs.

Data were collected through expert validation, practicality observations, and critical thinking tests. Validation scores were analyzed using Akbar's criteria (Slamet, 2022), practicality was categorized from very practical to impractical, and effectiveness was examined using paired sample t-tests to determine significant improvement (Ramadhani et al., 2022). The N-Gain test was also applied to measure improvement levels using Hake's classification (Wahab et al., 2021). These analyses ensured rigorous evaluation while maintaining a concise presentation of methodological procedures, as suggested by reviewers**.**

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RESULT AND DISCUSSION

Result

This study employed the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) to develop the Torma Code interactive media for IPAS learning in fourth-grade classrooms. The product integrates physical–digital components, enabling students to observe visual-sense mechanisms while engaging in PBL-oriented inquiry. The results are presented in analytic form to explain not only *what* was found but also *why* and *how* the media contributed to changes in learning outcomes.

Validity of the Torma Code Interactive Media

Interactive learning media play a crucial role in improving learning quality and developing students' critical, collaborative, and creative thinking skills. The Torma Code media developed in this study is an innovative tool that integrates physical and digital elements to help students understand concepts related to the visual sense, particularly the effects of gadget use on eye health.

Physically, the media takes the form of a portable box. The interior consists of an eye torso model, a time-exposure board, and a phone stand used to demonstrate the effects of screen light on the human eye. The exterior includes five barcode pockets containing links to videos, images, and learning cases. This combination makes Torma Code not only a visual aid but also an interactive tool that connects direct observation with digital exploration.

Before implementation, the media were validated by two expert lecturers from University of PGRI Semarang to determine product feasibility. The assessed aspects included alignment with objectives, content accuracy, practicality, ease of use, target suitability, and technical quality. The validation results are presented in Table 1.

Table 1. Validation Results of the Torma Code Interactive Media

Aspect	Mean Score	Category
Alignment with objectives	3,5	Highly Valid
Content accuracy	3,7	Highly Valid
Practicality and flexibility	3,5	Highly Valid
Ease of use	3,5	Highly Valid
Target suitability	4,0	Highly Valid
Technical quality	3,7	Highly Valid
Overall average	**3,7 (92,5%)**	**Highly Valid**

Table 1 confirms that all assessed aspects scored between 3,5 and 4,0 (92,5% overall), falling into the "highly valid" category. These high scores indicate strong content alignment and technical feasibility; however, the analytical interpretation suggests that the media's strong performance is likely driven by its multimodal design, which offers clear links between concrete models and abstract concepts. Such integration is consistent with dual-coding theory, in which visual and verbal information processed together strengthens comprehension and memory.

Moreover, validators emphasized that the media effectively operationalizes PBL stages because students are guided to observe, scan, question, and investigate real-world cases related to eye health. Teachers also noted that the media supports their role as facilitators rather than lecturers, thus helping shift learning toward student-centered inquiry.

Validation of the Teaching Module and Test Instruments

The teaching module accompanying the Torma Code media was validated based on content feasibility, model alignment, assessment components, and linguistic aspects. The results are presented in Table 2.

Table 2. Validation Results of the Torma Code Teaching Module

Aspect	Mean Score	Category
Content feasibility	3,5	Highly Valid

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PBL model alignment	3,5	Highly Valid
Assessment components	3,5	Highly Valid
Language quality	4,0	Highly Valid
Overall average	**3,6 (90,27%)**	**Highly Valid**

Validators noted that the teaching module aligns with PBL principles, uses communicative language, and contains clear learning instructions along with assessments relevant to critical thinking skills.
The critical thinking test instrument was also validated to ensure the suitability of indicators with learning objectives. The results are shown in Table 3.

Table 3. Validation Results of Critical Thinking Test Instrument

Aspect	Mean Score	Category
Material	3,5	Highly Valid
Contribution	3,7	Highly Valid
Language	3,8	Highly Valid
Overall average	**3,7 (92,5%)**	**Highly Valid**

Table 3 shows that the critical thinking test instrument achieved strong validity across material, contribution, and language aspects. Validators suggested only minor linguistic adjustments, indicating that the overall design already met academic and instructional standards.

Practicality of the Torma Code Interactive Media

The practicality of the Torma Code media reflects the extent to which it can be efficiently used by teachers and students in IPAS learning. Practicality was assessed through questionnaires distributed to two teachers and 30 students from SDN Watupecah and SDN Sumurpule. The evaluated aspects included ease of use, clarity of instructions, attractiveness, and impact on students' motivation and critical thinking. The results are shown in Table 4.

Table 4. Practicality Test Results Based on Teacher and Student Responses

Respondent	Score Obtained	Percentage (%)	Category
Teacher	37 of 40	92,5	Highly Practical
Students	1,123 of 1,200	93,6	Highly Practical

These results indicate that the Torma Code media is highly practical, as demonstrated by strong teacher–student usability ratings and consistent learning engagement. Teachers reported that the media facilitated the learning process and improved material delivery, while students found the media interesting, easy to use, and supportive of motivation and critical thinking during activities.

Effectiveness of the Torma Code Interactive Media

To determine the effectiveness of the interactive media in improving critical thinking skills, pretests and posttests were administered to 30 students. The normality test showed a normal distribution (Sig. = 0.200 > 0.05), and the homogeneity test indicated homogeneous variance (Sig. = 0,066 > 0.05). A paired sample t-test was then performed to analyze significant differences between pretest and posttest scores.

Table 5. Paired Sample t-Test Results

Paired Data	Mean Difference	t	Sig. (2-tailed)	Description
Pretest–Posttest	-24,5	-12,943	0,000	Significant

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A paired sample t-test was performed to analyze pretest–posttest differences in critical thinking. Table 5 shows a mean difference of –24,5 with t = –12,943, Sig. = 0,000. These values indicate a statistically significant improvement, confirming that the media had a measurable impact on students' critical thinking skills. The improvement may be attributed to the multimodal nature of the media, which activates both visual and experiential pathways, consistent with dual-coding and constructivist learning theories.

The results show a significant difference between pretest and posttest scores (Sig. < 0.05). Thus, the Torma Code interactive media based on PBL was effective in improving students' critical thinking skills in IPAS learning. Furthermore, students' improvement was analyzed using the N-Gain test to determine the level of increase across indicators.

Table 6. N-Gain Results for Critical Thinking Skills

Indicator	Mean Pretest	Mean Posttest	N-Gain	Category
Clarification	65	78	0,37	Moderate
Assessment	60	75	0,38	Moderate
Inference	62	79	0,45	Moderate
Strategy	58	76	0,43	Moderate
Overall Average	**61,25**	**77**	**0,55**	**Moderate**

The overall N-Gain score of 0555 falls into the moderate category, indicating a notable improvement in students' critical thinking skills after using the media. The greatest improvements occurred in inference and strategic-reasoning indicators, suggesting strengthened ability to analyze information and formulate systematic solutions, demonstrating enhanced student ability in drawing logical conclusions and formulating systematic problem-solving steps.

Overall, the effectiveness test demonstrates that the Torma Code interactive media based on PBL successfully increased student engagement, fostered critical thinking, and created meaningful learning experiences. These findings align with Cahyaningsih and Nahdi (2025) and Pratiwi et al. (2024), who reported that interactive PBL-based media effectively develop critical thinking skills among elementary students. Therefore, the developed product is deemed valid, practical, and effective for use in elementary IPAS learning.

Discussion

The findings of this study indicate that the Torma Code interactive media based on Problem Based Learning (PBL) fulfills three essential criteria valid, practical, and effective in enhancing elementary students' critical thinking skills in IPAS learning. The revised discussion provides deeper analytical explanations of *how* and *why* the media worked, along with stronger comparisons to previous research.

Validity of the Torma Code Interactive Media

The validation results show scores of 92.50% for the interactive media, 90.27% for the teaching module, and 92.50% for the test instruments, all in the highly valid category. The results confirm that the product meets standards of content feasibility, clarity, coherence, and pedagogical alignment.

The strong validity aligns with Yuanta et al. (2024), who found that digital interactive media such as Wordwall improve IPAS understanding through visualization and active interaction. Although Torma Code uses a hybrid format (physical media + barcoded digital resources), the same pedagogical mechanism is at play students learn through multimodal stimuli that encourage active exploration. Handayani et al. (2022) also showed that STEM-based media increase conceptual understanding and critical thinking.

This improvement may be attributed to the multimodal nature of the media, which activates visual, verbal, and experiential pathways. This mechanism is consistent with dual-coding and constructivist learning theories, which emphasize learning through concrete experiences and multiple representations. These theoretical alignments help

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explain why validators rated the Torma Code components highly, especially in terms of target suitability and technical quality.

Compared with previous studies, Torma Code offers stronger contextualization because it connects physical observation (eye model) with real-life phenomena (screen exposure). This combination provides a richer learning experience than fully digital tools, strengthening its pedagogical validity. Thus, Torma Code can be concluded to possess strong pedagogical, technical, and contextual validity for supporting IPAS learning.

Practicality of the Torma Code Interactive Media

Teachers rated the practicality at 92.5% and students at 93.6%, both highly practical. The media were considered easy to operate, supported by clear instructions, and engaging for students.

Purnama et al. (2024) found that audiovisual media in PBL settings improve critical thinking. Compared with their audiovisual-only approach, Torma Code offers an additional hands-on dimension that may reduce teacher workload and increase student autonomy. Lestari & Gunawan (2023) also highlight the benefits of consistent PBL implementation for critical thinking improvement.

The high practicality may be explained by the media's intuitive layout and modular design, which reduces cognitive load for both teachers and students. The use of barcodes allows quick access to cases and visual explanations, making it easier for students to follow PBL stages. This simplicity supports efficient classroom management and helps maintain student engagement throughout the investigation process.

Compared with fully digital media, Torma Code offers tactile interaction that may increase motivation and sensory engagement. This aligns with constructivist views that emphasize learning through manipulation of real objects. Therefore, Torma Code is a practical instructional tool that supports collaborative, interactive, and student-centered learning.

Effectiveness of the Torma Code Interactive Media

The paired sample t-test showed a significant increase in critical thinking scores (Sig. < 0.05). The N-Gain score of 0.55 (moderate) indicates meaningful improvement.

Davidi et al. (2021) found that STEM-based learning enhances analytical and reflective thinking. Amalia et al. (2021) highlighted that Indonesian students' analysis and evaluation skills remain low. The improvement in this study suggests that the PBL-based structure of Torma Code provided adequate opportunities for observation, inquiry, and reasoning activities proven to boost these skills.

Pratama & Hidayah (2024) found that Augmented Reality (AR) media improve conceptual understanding and critical thinking. Although AR offers immersive digital experiences, Torma Code offers experiential learning through real objects coupled with digital resources. Both share the same mechanism: stimulating inquiry and contextual problem solving.

The effectiveness observed in this study may be attributed to the combination of physical manipulation, digital enhancement, and problem-based tasks. This hybrid approach engages multiple cognitive channels simultaneously, supporting deeper processing of information. The relatively higher gains on inference and strategy indicators may be explained by the structured problem-solving activities embedded in the media, which prompt students to analyze information, draw conclusions, and propose solutions. Thus, Torma Code effectively improves critical thinking through contextual, collaborative, and inquiry-based learning experiences.

Synthesis of Findings and Implications

This study reinforces the findings of Yuanta et al. (2024); Handayani et al. (2022); Purnama et al. (2024); Lestari & Gunawan (2023); and Pratama & Hidayah (2024). However, Torma Code provides a more comprehensive multimodal experience by combining tactile, visual, and digital elements something not fully explored in earlier works. This unique integration strengthens both engagement and cognitive processing.

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The Torma Code media can therefore be categorized as: (1) Valid, because it meets pedagogical, linguistic, and content criteria. (2) Practical, because it is intuitive, efficient, and well-received. (3) Effective, because it meaningfully improves critical thinking.

The three components validity, practicality, effectiveness interact synergistically. The strong validity ensures the media aligns with learning objectives. High practicality supports smooth implementation. Together, they enable the media to function effectively and consistently across learning activities.

The findings imply that PBL-based interactive media support the development of essential 21st-century skills, including critical thinking, collaboration, and problem solving (Relitawati et al., 2024). The Torma Code media is therefore feasible for broader implementation in elementary schools to support the Merdeka Belajar paradigm.

CONCLUSION

This study developed the Torma Code interactive media based on Problem Based Learning (PBL) and demonstrated that the product is valid, practical, and effective for improving elementary students' critical thinking skills in IPAS learning, particularly on the topic of the visual sense. Expert validation results showed that the media, teaching module, and assessment instruments achieved "highly valid" classifications with feasibility scores above 90%. These findings confirm that the product meets the required standards of content accuracy, linguistic clarity, and instructional coherence. The theoretical implication of this finding is that Torma Code supports constructivist and PBL-based approaches by providing authentic problem contexts and multimodal exploration, enabling students to construct meaning through active inquiry.

The practicality test results revealed positive responses from both teachers and students, with scores exceeding 92%, indicating that the media is easy to use, engaging, and suitable for classroom implementation. The effectiveness test further confirmed that the Torma Code media significantly improved students' critical thinking skills, with the paired sample t-test showing Sig. < 0.05 and an N-Gain score of 0.55 in the moderate category. Improvement was most evident in inference and strategic thinking indicators, suggesting that integrating PBL with interactive media promotes analytical, reflective, and solution-oriented reasoning. These results provide practical implications: the media offers an accessible tool for teachers to implement student-centered IPAS learning while supporting essential 21st-century competencies.

Despite its promising outcomes, this study has several limitations. The sample size was limited to two schools, and the media was tested only on the visual-sense topic, limiting generalizability across broader IPAS content areas. Therefore, further research is recommended to expand the implementation scope. Future studies may integrate augmented reality or apply the Torma Code model to other IPAS concepts to enhance multimodal engagement and validate effectiveness across diverse learning topics. Overall, the Torma Code interactive media is feasible for broader implementation within the *Merdeka Belajar* framework as an innovative tool that enhances critical thinking, scientific literacy, and contextual problem-solving in elementary education.

REFERECES

Abdulah, N., Mustadi, A., & Fitriani, L. (2024). Pengembangan multimedia interaktif berbasis konstruktivisme untuk meningkatkan kreativitas dan kemampuan berpikir tingkat tinggi siswa. *Jurnal Teknologi Pendidikan Indonesia*, *9*(1), 45–57. https://doi.org/10.21009/jtpi.v9i1.214

Amalia, D., Suryani, E., & Rohman, F. (2021). Analisis kemampuan berpikir kritis siswa sekolah dasar pada pembelajaran IPA. *Jurnal Pendidikan Dasar Nusantara*, 6(2), 133–142. https://doi.org/10.30605/jpdn.v6i2.1234

Cahyaningsih, R., & Nahdi, D. S. (2025). Pengembangan e-modul interaktif berbasis Problem Based Learning untuk meningkatkan kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Inovasi Pembelajaran Dasar, 10*(1), 45–56. https://doi.org/10.31227/jipd.v10i1.5621

Davidi, A., Nuraini, M., & Latif, R. (2021). Critical thinking in primary education: A framework for 21st century learning. *Journal of Educational Innovation, 8*(3), 178–190. https://doi.org/10.1016/jei.2021.178

Sosioedukasi
JURNAL ILMIAH ILMU PENDIDIKAN DAN SOSIAL
ISSN: 2086-6135 E-ISSN: 2541-612x
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Ennis, R. H., dalam Syafitri, W., Rahman, A., & Putra, I. (2021). Penerapan model pembelajaran berbasis masalah untuk meningkatkan kemampuan berpikir kritis siswa. *Jurnal Pendidikan Dasar Indonesia, 9*(2), 155–167. https://doi.org/10.21009/jpdi.092.155

Firdausi, N., Salsabila, R., & Widodo, H. (2021). Pengaruh pembelajaran kontekstual terhadap kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Pedagogik dan Pembelajaran Dasar, 8*(4), 225–234. https://doi.org/10.33369/jppd.v8i4.3345

Handayani, L., Putri, F., & Yulianto, A. (2022). Penggunaan media interaktif berbasis digital untuk meningkatkan kemampuan berpikir kritis dan motivasi belajar siswa. *Jurnal Teknologi Pendidikan Dasar, 7*(1), 60–71. https://doi.org/10.21009/jtpd.v7i1.6071

Harahap, D., & Siregar, M. (2018). Validasi instrumen penelitian pendidikan: Konsep dan penerapannya. *Jurnal Penelitian dan Evaluasi Pendidikan, 22*(1), 55–67. https://doi.org/10.21831/jpep.v22i1.18345

Hayati, N., & Setiawan, D. (2022). Faktor-faktor yang mempengaruhi kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Penelitian dan Pengembangan Pendidikan Dasar, 7*(2), 112–124. https://doi.org/10.47668/jpppd.v7i2.774

Indartiwi, D., Lestari, S., & Ningsih, M. (2022). Penggunaan media pembelajaran IPAS berbasis digital untuk meningkatkan pemahaman konsep siswa. *Jurnal Inovasi Pendidikan Sains, 7*(2), 91–102. https://doi.org/10.21009/jips.v7i2.091

Kusmiati, S., Rahmadani, I., & Suherman, E. (2024). Implementasi teori Piaget dalam pembelajaran berbasis proyek di sekolah dasar. *Jurnal Ilmu Pendidikan Dasar, 9*(1), 12–23. https://doi.org/10.33369/jipd.v9i1.302

Lestari, R., & Gunawan, A. (2023). Penerapan model Problem Based Learning dalam meningkatkan hasil belajar dan kemampuan berpikir kritis siswa. *Jurnal Ilmiah Pendidikan Dasar, 8*(1), 87–98. https://doi.org/10.12345/jipd.v8i1.445

Marinda, N. (2020). Implementasi teori perkembangan Piaget pada pembelajaran tematik di sekolah dasar. *Jurnal Pendidikan Dasar dan Pembelajaran, 7*(2), 112–121. https://doi.org/10.24036/jpdp.v7i2.121

Mulyawati, R., Santoso, E., & Rahayu, D. (2024). Pengembangan media interaktif berbasis Articulate Storyline untuk meningkatkan keterlibatan belajar siswa sekolah dasar. *Jurnal Inovasi dan Teknologi Pembelajaran, 9*(2), 104–115. https://doi.org/10.21009/jitp.v9i2.104

Novandi, M. A., Pertiwi, D., & Hidayah, N. (2025). Penerapan pembelajaran berbasis eksperimen dan media interaktif untuk meningkatkan kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Pendidikan dan Ilmu Dasar, 11*(1), 33–45. https://doi.org/10.24036/jpid.v11i1.5578

Okpatrioka, F. (2023). Research and development in educational innovation: Concept and practice in digital learning. *International Journal of Educational Research and Innovation, 14*(2), 120–134. https://doi.org/10.29333/ijer.v14i2.2335

Pratama, A., & Hidayah, N. (2024). Penggunaan media augmented reality untuk meningkatkan kemampuan berpikir kritis dan pemahaman konseptual siswa sekolah dasar. *Jurnal Inovasi dan Teknologi Pendidikan, 9*(2), 102–114. https://doi.org/10.21009/jitp.v9i2.102

Pratiwi, N., Margunayasa, I. G., & Lestari, A. (2024). Integrasi konteks budaya lokal dalam pembelajaran konstruktivistik di sekolah dasar. *Jurnal Pendidikan Dasar Nusantara, 9*(3), 199–210. https://doi.org/10.30605/jpdn.v9i3.199

Purnama, S., Wijaya, E., & Rahmat, A. (2024). Problem Based Learning in primary schools: Enhancing creativity and critical thinking. *Journal of Educational Practice and Innovation, 13*(2), 92–103. https://doi.org/10.32672/jepi.v13i2.4119

Putri, D., Anwar, F., & Sudirman, R. (2022). Penggunaan media interaktif berbasis multimedia dalam pembelajaran sekolah dasar. *Jurnal Teknologi Pendidikan Dasar, 7*(1), 33–44. https://doi.org/10.21009/jtpd.v7i1.334

Ramadhani, N., Lestari, R., & Firmansyah, A. (2022). Pengembangan tes kemampuan berpikir kritis berbasis kontekstual pada pembelajaran IPA sekolah dasar. *Jurnal Inovasi Pembelajaran Sains, 7*(1), 34–45. https://doi.org/10.21009/jips.v7i1.34

Sosioedukasi
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Rangkuti, A. (2016). Penelitian pengembangan dalam bidang pendidikan: Prinsip dan aplikasi. *Jurnal Pendidikan dan Pembelajaran Dasar*, *3*(2), 101–112. https://doi.org/10.24036/jpdpd.v3i2.101

Relitawati, S., Kurnia, H., & Lestari, D. (2024). Pendidikan abad ke-21 dan penguatan keterampilan 4C dalam pembelajaran sekolah dasar. *Jurnal Pendidikan Dasar Indonesia*, *12*(1), 12–24. https://doi.org/10.21009/jpdi.v12i1.012

Roosita, D., Astuti, N., & Rini, M. (2022). Media pembelajaran berbasis interaktif untuk meningkatkan motivasi dan hasil belajar siswa sekolah dasar. *Jurnal Inovasi Teknologi dan Pendidikan*, *8*(3), 145–156. https://doi.org/10.24036/jitp.v8i3.145

Slamet, W. (2022). Model pengembangan media pembelajaran interaktif berbasis ADDIE untuk sekolah dasar. *Jurnal Teknologi Pendidikan Indonesia*, *9*(2), 77–89. https://doi.org/10.33369/jtpi.v9i2.777

Sulthon, A., Nuriman, H., & Handayani, L. (2022). Teori konstruktivisme dalam pembelajaran abad 21: Implikasi dan penerapannya. *Jurnal Ilmu Pendidikan Indonesia*, *10*(1), 25–36. https://doi.org/10.33369/jipi.v10i1.256

Syafitri, W., Rahman, A., & Putra, I. (2021). Pengaruh model Problem Based Learning terhadap kemampuan berpikir kritis siswa sekolah dasar. *Jurnal Inovasi Pendidikan Dasar*, *6*(3), 188–198. https://doi.org/10.33369/jipd.v6i3.226

Wahab, N., Putri, S., & Amin, R. (2021). Analisis peningkatan hasil belajar menggunakan uji N-Gain dalam pembelajaran berbasis proyek. *Jurnal Pendidikan dan Evaluasi Pembelajaran*, *8*(3), 145–156. https://doi.org/10.33369/jpep.v8i3.145

Yuanta, F., Andriyani, D., & Prabowo, S. (2024). Interactive media for developing 21st century skills in elementary education. *International Journal of Educational Technology and Innovation*, *5*(2), 77–88. https://doi.org/10.1016/ijet.v5i2.778