Recieved: 06-10-2024 | Revised: 07-12-2024 | Accepted: 31-01-2025

ARTICLE
Volume 2, Number 2, 2025 pp. 20-29
E-ISSN: 3025-2741
Doi:

EduFuture: Journal of Future Education

Transformation Of Science Learning Through Augmented Reality: Its Impact on Critical Thinking Abilities of Elementary School Students

Hasna Muthi Luthfiyah [1] Dede Margo Irianto[2] Yusuf Tri Herlambang[3]
Diki Somantri [4] Tono Sutanto[5] Yadi Suryadi[6]

Affiliation:
[1,2,3,4,5,6] Universitas Pendidikan Indonesia, Bandung, Indonesia

Correspondence:
Jl. Raya Cibiru KM 15 Bandung 40393, Jawa Barat, 40625, Indonesia.
Email: luthfiyahhasnamth@upi.edu

Funding information:
Universitas Pendidikan Indonesia, Indonesia, Grant/Award Number: Latitude) -6.9156, Longitude 107.7184,

Abstract
Low critical thinking skills among elementary school students regarding abstract concepts, such as Earth and Moon movements, present a significant challenge in implementing the Merdeka Curriculum, which emphasizes critical reasoning. This study aims to analyze the influence of Assemblr EDU-based Augmented Reality (AR) on enhancing the critical thinking skills of sixth-grade students. A quasi-experimental method with a non-equivalent pre-test post-test control group design was utilized, involving 56 students divided into experimental (n=28) and control (n=28) groups. Data collection instruments included critical thinking tests and observation sheets, followed by statistical analysis using Wilcoxon, Mann-Whitney, and N-Gain Score tests. The findings revealed a substantial disparity in outcomes; the experimental group achieved a mean post-test score of 91.25, significantly higher than the control group's 57.86. Furthermore, the N-Gain analysis showed that Assemblr EDU reached an effectiveness level of 84.7% (High category), whereas the control group only attained 27.9% (Low category). These results demonstrate that 3D visualization through AR effectively bridges the cognitive transition from the concrete operational to the abstract thinking stages. Consequently, this study provides a strong recommendation for educational practitioners to integrate AR-based media into Science (IPAS) instruction to foster students' analytical, inferential, and evaluative competencies optimally at the primary education level.

Keywords: Augmented Reality, Assemblr EDU, Critical Thinking, Science (IPAS), Elementary Education

1. INTRODUCTION

The dynamic advancement of Science and Technology (IPTEK) in the current digital era has fundamentally shifted the educational paradigm, where technology is no longer merely a supporting tool but an inherent element in the cognitive activities of modern humans. The massive presence of technology demands that society develop an adaptive

mindset and be sensitive to highly dynamic environmental changes (Arbi & Amrullah, 2024; Handayani, 2024; Sartini et al., 2024). However, behind this progress, a phenomenon of degraded thinking quality, or "brain rot," has emerged, caused by an over-reliance on instant technological features, eroding people's analytical abilities to distinguish between fact and opinion (Ghifari & Ash, 2025; Sulianta, 2025). This situation poses a major challenge for the world of education, which aims to equip the next generation with stronger intellectual skills.

In line with this, critical thinking skills have now become a primary focus in the global education system as a foundation for accurately understanding the world and making rational decisions. In Indonesia, this urgency is reflected in the 2035 education vision, which targets the creation of Pancasila students with strong critical reasoning skills. However, the reality on the ground shows that elementary school students' critical thinking skills remain low, characterized by their inability to formulate in-depth questions or express evidence-based opinions (Faidah et al., 2022; Martir et al., 2024; Putri & Azzizah, 2025). This low achievement indicates a gap in the cognitive stimulation process at the elementary level.

This problem is increasingly evident in Natural and Social Sciences (IPAS) learning, particularly in abstract topics such as the motion of the Earth and the Moon. Elementary school-aged students, who, according to Jean Piaget's theory, are in the concrete operational stage, often experience significant difficulty visualizing astronomical phenomena that cannot be physically touched (Marinda, 2020; Susanto & Wulandari, 2024). As a result, profound misconceptions arise because students are forced to understand the logic of complex cause-and-effect relationships without any tangible representations of objects (Fitriani, 2024). This mismatch between students' cognitive characteristics and the complexity of the material requires learning media solutions capable of bridging these abstract concepts.

This obstacle is exacerbated by the dominant use of conventional learning media and lecture methods, which tend to make learning teacher-centered. Static media such as textbooks or traditional planetarium physical demonstrations often fail to simultaneously convey dynamic images of the rotation and revolution of celestial bodies (Rakhman et al., 2024; Ramadhani et al., 2023). This limited visualization results in low student mental engagement in exploring information, thus under-stimulating the ability to make inferences and critical evaluations. Therefore, a transformation of learning media is needed to make it more interactive and adaptive to current technological developments. Furthermore, democracy guides individuals to become responsible citizens who are actively engaged in the functioning of the state. Law-abiding citizens are understood as individuals who possess knowledge and abstract concepts. Through this research, I aim to demonstrate that the integration of Assemblr EDU with an inquiry approach can create an immersive learning experience, where students are no longer passive recipients of information but active explorers capable of constructing a critical understanding of science. This article focuses on providing empirical evidence regarding the extent to which AR technology can transform the quality of elementary school students' thinking on the topic of the motion of the Earth and the Moon.

As a solution to this problem, Augmented Reality (AR) technology has emerged as an innovative medium capable of projecting three-dimensional virtual objects into real-time environments. The use of AR in elementary school education has been proven to increase learning interactivity because students can see, experience, and manipulate previously abstract simulation models (Juwairiah et al., 2025; Saepudin & Wulandari, 2023). Through AR visualization, difficult-to-imagine concepts such as the solar system can be presented concretely, encouraging students to analyze visual information, form hypotheses, and seek answers through exploration (Puspita et al., 2025; Rahmanda, 2025).

Despite the enormous potential of AR, a major challenge currently faced is the limited availability of relevant, high-quality content easily accessible to elementary school teachers (Azizah et al., 2025; Wijayati, 2024; Zaky et al., 2024). Most previous research has focused on general AR application development without specifically examining the effectiveness of specific platforms, such as Assemblr EDU, in

improving indicators of systematic critical thinking. This gap highlights the need for further research exploring how Assemblr EDU's interactive features can effectively stimulate students' analytical and self-regulation skills in the context of science learning.

Based on this urgency and research gap, I believe that the use of Assemblr EDU-based Augmented Reality is not simply an attempt to digitize materials, but rather a pedagogical strategy to facilitate students' cognitive transition from concrete thinking to character in accordance with the laws enacted by their country. Consequently, law-abiding citizens demonstrate compliance and act appropriately under the law, contributing to a harmonious and conducive civic life. PKn also fosters a sense of nationalism, defined as citizens who are loyal, love their country wholeheartedly, and are willing to dedicate their lives in service to the nation (Yunansah et.al., 2022; Wahid et.al., 2023; Wahid & Asrina, 2024).

Nationalism through PKn is particularly crucial for all citizens to embrace, especially in light of globalization and the boundless changes occurring in the international arena (Yunansah et.al., 2022; Wahid et.al., 2023; Wahid & Asrina, 2024). As such, countries, including Indonesia, must remain vigilant against transformative currents that could have negative impacts if left unaddressed. In many countries, including Indonesia, citizenship-based teaching and learning activities have been implemented to mitigate adverse influences arising from globalization. In this context, PKn plays a role in presenting knowledge about the state and guiding individuals in conducting themselves within social environments. PKn encompasses values of nationalism that foster citizens who are attentive to governance and national management. The concept of nationalism can safeguard the nation from divisive forces originating both internally and externally. Therefore, nationalism through PKn can be said to create a unifying bond among all citizens in pursuit of the nation's goals (Herlambang, 2021; Herlambang & Abidin, 2022; Permana et.al., 2024).

2. METHOD

Penelitian ini menggunakan pendekatan kuantitatif dengan metode quasi-experiment melalui desain Nonequivalent Pre-test Post-test Control Group (Creswell & Poth, 2016; Purwono et al., 2019; Sugiyono, 2010). Populasi penelitian adalah siswa kelas VI Sekolah Dasar, dengan sampel sebanyak 56 siswa yang dipilih menggunakan teknik purposive sampling. Sampel dibagi menjadi dua kelompok: kelas eksperimen (n=28) yang menggunakan media AR Assemblr EDU, dan kelas kontrol (n=28) yang menggunakan alat peraga planetarium statis.

Instrumen penelitian berupa tes kemampuan berpikir kritis (20 butir soal pilihan ganda) yang mencakup indikator interpretasi, analisis, evaluasi, inferensi, dan regulasi diri (Facione, 2011, 2015). Selain itu, lembar observasi digunakan untuk memantau aktivitas siswa selama intervensi (10 kali pertemuan: 5x dikelas kontrol, 5x dikelas eksperimen). Analisis data dilakukan menggunakan uji normalitas Shapiro-Wilk, uji homogenitas, serta uji non-parametrik Wilcoxon dan Mann-Whitney melalui SPSS 25 karena data tidak berdistribusi normal. Efektivitas perlakuan diukur menggunakan rumus N-Gain Score.

3. RESULT AND DISCUSSION

Result

The presentation of the research results begins with the presentation of descriptive statistical data to provide a general overview of students' critical thinking skills before and after the intervention. Based on the results of the pre-test, it was found that both groups of study subjects started from a relatively similar starting point, but were in the low category. The experimental group had an average score of 50.86 with a standard deviation of 15.84, while the control group had an average score of 41.79 with a standard deviation of 13.20. This data indicates that before the instructional media intervention, most sixth-grade students still struggled to answer questions requiring

analytical and inference skills on the motion of the Earth and the Moon.

After the different treatments, there was a marked difference in achievement between the two classes. In the experimental class, which used Assemblr EDU-based Augmented Reality (AR), the average student score jumped dramatically to 91.25, with a score range of 75 to 100. This improvement indicates that almost all students in the experimental class were able to achieve maximum completion criteria after interacting with the interactive 3D model. In contrast, in the control class using conventional planetarium media, the average post-test score was only 57.86. While this was an improvement from the initial test score, it was still far below the expected competency standards compared to the class that received AR technology intervention. To ensure the accuracy of the data analysis, the researchers conducted statistical prerequisite tests, including normality and homogeneity tests. Based on the Shapiro-Wilk test results, the significance value (Sig.) for all pre-test and post-test data in both classes was below 0.05 ($p < 0.05$). This result concluded that the distribution of the research data was not normal, so subsequent comparative analysis switched to non-parametric statistics instead of parametric statistics. Furthermore, the homogeneity of variance test showed a Sig. value of 0.014, indicating that the data variance between the experimental and control classes was not homogeneous, thus strengthening the researchers' decision to use the Wilcoxon and Mann-Whitney tests for hypothesis testing.

The next step was to test the first and second hypotheses using the Wilcoxon Signed Rank Test to determine the significance of improvements in each class. The analysis results showed an Asymp. Sig. value (2-tailed) of 0.000 for both groups, indicating a significant effect of each learning method on students' critical thinking skills. However, when viewed from the mean rank value, the experimental class recorded a score of 14.50 without a single student experiencing a decrease in grades (negative ranks 0). This proves that the Assemblr EDU intervention had a uniform and consistent positive impact on all subjects in the experimental class, compared to the control class, which still recorded a decrease in grades in some students.

To answer the research question regarding the difference in effectiveness between the two methods, a Mann-Whitney U test was conducted. The test results showed an Asymp. Sig. (2-tailed) value of 0.000 with a Z-value of -6.202. Because the significance value was far below 0.05, the null hypothesis (H0) was rejected and the alternative hypothesis (H1) was accepted, confirming that there was a very significant difference in critical thinking skills between students learning with the Assemblr EDU AR media and students learning using the static planetarium media. This difference was evident from the very wide difference in mean ranks, with the experimental class achieving a score of 41.89 while the control class only achieved 15.11, indicating a striking disparity in the quality of learning outcomes. The final analysis was conducted by calculating the N-Gain Score to measure the absolute level of effectiveness of the intervention. The calculation results showed that the experimental class obtained an average N-Gain score of 84.74% or 0.84 which falls into the "Effective" category and a "High" level of improvement. On the other hand, the control class only obtained an average N-Gain score of 27.92% or 0.27 which falls into the "Ineffective" category with a "Low" level of improvement. This highly significant percentage comparison (a difference of 56.82%) is strong empirical evidence that the use of Assemblr EDU-based Augmented Reality is substantially superior and is able to accelerate students' critical thinking skills in understanding complex astronomical concepts in elementary school.

Discussion

The findings of this study indicate that the integration of Augmented Reality (AR) through the Assemblr EDU platform has a transformative impact on elementary school students' critical thinking skills on the topic of Earth and Moon Motion. The experimental class' N-Gain Score of 84.74% demonstrates that dynamic visual stimulation can construct a deeper understanding of concepts than conventional media. This phenomenon aligns with the view

that the use of AR in education encourages more active cognitive engagement because students can interact directly with digital models (Fadhilah & Nuriza, 2025; Suryaman & Ningsih, 2025; Tarigan, 2025). This success also confirms previous research that AR media is effective in enhancing the understanding of science concepts that are difficult to visualize with static media (Farwati et al., 2025; Juwairiah et al., 2025; Kartini et al., 2025).

The significance of the improvement in the experimental class is theoretically closely related to the cognitive transition of elementary school students from the concrete operational stage to the formal operational stage. Based on Jean Piaget's theory of cognitive development, students aged 7-12 require physical objects or tangible representations to understand the logic of cause-and-effect relationships (Babullah, 2022; Marinda, 2020; Mifroh, 2020; Nainggolan & Daeli, 2021; Susanto & Wulandari, 2024). In this context, AR acts as a cognitive bridge, transforming abstract astronomical objects into semi-concrete experiences that can be independently manipulated (Dafit et al., 2025; Komarudin, 2025). The use of this sophisticated artificial media plays a crucial role in ensuring the transition from concrete to abstract operational thinking is effectively bridged without causing any disruption (Julianto, 2024; Kusum et al., 2023).

The interactivity characteristics offered by Assemblr EDU have also been shown to shift learning patterns from passive to active (student-centered learning). Through the 3D model exploration feature, students not only observe the phenomena of rotation and revolution but are also encouraged to ask exploratory questions, such as the reasons for the differences in day and night duration (Reffiane et al., 2025; Setiawan et al., 2025). This aligns with the principles of science learning in the Independent Curriculum, which emphasizes process skills and independent discovery (Pebriyanti & Siagian, 2024; Viqri et al., 2024). Dynamic interactions with digital content stimulate students' curiosity, a key prerequisite for developing critical reasoning skills in elementary school (Dewindri & Sa'diah, 2025; Rahim, 2023; Wiguna & Sudarti, 2024).

More specifically, the improvement in critical thinking skills in this study was strongly reflected in the analysis and inference indicators. Based on observations, students were able to draw logical conclusions about the impact of Earth's motion based on visual simulations they observed on their device screens (Facione, 2011). This capability emerges because AR provides real-time visual feedback, allowing students to independently evaluate their understanding if misinterpretations occur (Cynthia & Sihotang, 2023). Critical thinking in this context is a result of psychological development involving higher-order cognition, where students are able to synthesize visual information into meaningful knowledge (Atamou et al., 2025; Rahim, 2023).

On the other hand, the stagnant achievement of the control class in the low category (27.92%) indicates that static media and conventional methods are no longer adequate for teaching complex astronomical concepts. Reliance on lecture methods leads to teacher-centered learning, thus depriving students of opportunities to practice their 21st-century skills (Ali et al., 2024; Dulyapit & Lestari, 2024). The use of traditional physical planetarium props often fails to accurately represent scale and dynamic movement, which can actually trigger intellectual confusion in students (Zuhaida, 2023). This proves that without the support of innovative technology, the internalization of science knowledge in elementary school children will be hampered by the limitations of their spatial imagination (Asriani & Rahmadana, 2024; Lokollo et al., 2024).

The implementation of Assemblr EDU in this study also highlights the importance of teachers' digital competence in designing learning experiences. The effectiveness of AR depends heavily on how teachers integrate the technology into structured inquiry-based learning scenarios (Prayogi, 2020). Teachers who are able to facilitate critical discussions after exploring digital media will help students strengthen their memory retention and conceptual understanding (Masrur & Maghfirah, 2025). Therefore, this success is influenced not only by the sophistication of the media, but also by the harmony between technology, content, and appropriate

pedagogical methods, known as Technological Pedagogical Content Knowledge (TPACK) (Ariadi et al., 2023; Oktafiani & Haka, 2024; Somantri & Komala Putri, 2023).

As a final implication, these findings emphasize that mastering critical thinking skills through AR media is a long-term investment in preparing students to face 21st-century challenges. The 4C competencies (Critical Thinking, Creativity, Communication, Collaboration) can grow optimally in a learning ecosystem that supports the wise exploration of technology (Effendi et al., 2024). Critical thinking skills serve as a foundation for other life skills, enabling students to sort information and make rational decisions in an era of information disruption (Naila Nafaul Faiza, 2024). Thus, the integration of AR in basic education should be seen as an urgent need to improve the quality of graduates who possess the profile of resilient Pancasila Students (Huda, 2025; Patmaniar et al., 2024).

4. CONCLUSION

Based on the data analysis and discussion, it can be concluded that the use of Augmented Reality (AR) media based on Assemblr EDU significantly improved the critical thinking skills of sixth-grade elementary school students on the topic of Earth and Moon Motion. This is evidenced by the average post-test score of the experimental class (91.25), which significantly exceeded that of the control class (57.86). The superiority of this media is also confirmed by the N-Gain Score of 84.74%, placing the use of Assemblr EDU in the high effectiveness category, far surpassing the use of static teaching aids, which only achieved an effectiveness level of 27.92%.

Theoretically, this study demonstrates that AR technology can act as a cognitive catalyst that bridges students' limitations in understanding abstract astronomical concepts. Interactive three-dimensional visualizations enable students to independently explore and dynamically simulate natural phenomena, thereby stimulating critical thinking indicators, particularly in the aspects of analysis, inference, and evaluation. This success confirms that the transformation of learning media from conventional to digital-based is crucial in supporting the achievement of the Pancasila Student Profile, particularly in the critical reasoning dimension at the elementary level.

As a practical implication, this study recommends that elementary school teachers integrate Augmented Reality platforms such as Assemblr EDU into science (IPAS) learning to create a student-centered learning ecosystem. Schools are expected to support the provision of digital infrastructure and TPACK competency training for teachers so that the use of this technology can be implemented sustainably. Future researchers are advised to explore the effectiveness of AR on other variables, such as learning motivation or scientific literacy, with a broader scope of research subjects to enrich the body of knowledge on innovative learning media development.

5. REFERENCES

Ali, A., Apriyanto, A., Haryanti, T., & Hidayah, H. (2024). Metode Pembelajaran Inovatif: Mengembangkan Teknik Mengajar Di Abad 21. PT. Sonpedia Publishing Indonesia.

Arbi, Z. F., & Amrullah, A. (2024). Transformasi sosial dalam pendidikan karakter di era digital: Peluang dan tantangan. Social Studies in Education, 2(2), 191–206.

Ariadi, A., Suriansyah, A., & Purwanti, R. (2023). Implementasi Model Pembelajaran Excellent Dan Media Augmented Reality Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa. Adi Widya: Jurnal Pendidikan Dasar, 8(2), 122–137.

Asriani, W., & Rahmadana, A. (2024). Analysis of Prospective Primary School Teachers' Innovative Ideas on How to Teach Science So that Students Enjoy It More: Analisis Ide Inovatif Calon Guru Sekolah Dasar Tentang Cara Mengajarkan IPA Agar Lebih di Senangi Oleh Siswa. SEARCH: Science Education Research Journal, 3(1), 36–45.

Atamou, M. L., Kadjakoro, J. D. M., Woli, I. S. B., Nafie, R. M. H., Tafuli, Y. M., & Sesfao, M. I. (2025). Pemanfaatan Media

Pembelajaran Berbasis Kognitif untuk Meningkatkan Proses Berpikir Siswa. ADIBA: Journal of Education, 4(4), 113–125.

Azizah, S. M. N., Suswanto, H., Ningrum, G. D. K., Aprilianto, N. D., Utama, M. A., Afaf, R. S. H. T., Anang, R. R. A., Baharudin, M. N., Nisrina, S. H., & Nurkolis, V. (2025). Workshop Peran Augmented Reality dalam Pengembangan Media Pembelajaran Inovatif di Sekolah Menengah Mitra PPG. Jurnal Masyarakat Madani Indonesia, 4(3), 733–746.

Babullah, R. (2022). Teori perkembangan kognitif Jean Piaget dan penerapannya dalam pembelajaran. Epistemic: Jurnal Ilmiah Pendidikan, 1(2), 131–152.

Creswell, J. W., & Poth, C. N. (2016). Qualitative inquiry and research design: Choosing among five approaches. Sage publications.

Cynthia, R. E., & Sihotang, H. (2023). Melangkah bersama di era digital: pentingnya literasi digital untuk meningkatkan kemampuan berpikir kritis dan kemampuan pemecahan masalah peserta didik. Jurnal Pendidikan Tambusai, 7(3), 31712–31723.

Dafit, F., Fitriani, F., Lingga, L. J., Febliza, A., Yoana, A., & Sakila, N. (2025). Pendampingan Literasi Membaca Berbasis Augmented Reality di Sekolah Dasar. Jurnal Abdidas, 6(6), 777–793.

Dewindri, K. F., & Sa'diah, A. H. (2025). Strategi Pembelajaran Deep Learning dalam Mengembangkan Rasa Ingin Tahu Siswa Sekolah Dasar. JOEBAS: Journal of Education, Behavior, and Social Studies, 1(1), 20–28.

Dulyapit, A. D. A., & Lestari, S. (2024). Metode ceramah dalam pendidikan Madrasah Ibtidaiyah: Analisis literatur tentang implementasi dan dampaknya. Al-Ihtirafiah: Jurnal Ilmiah Pendidikan Guru Madrasah Ibtidaiyah, 45–56.

Effendi, M. I., Elmunsyah, H., & Widiyanti, W. (2024). Peran Technological Pedagogical Content Knowledge (TPACK) terhadap Ketercapaian 4C Skills (Critical Thinking, Creative Thinking, Collaboration, and Communication) Siswa SMK. Didaktika: Jurnal Kependidikan, 13(001 Des), 435–444.

Facione, P. A. (2011). Critical thinking: What it is and why it counts. Insight Assessment, 1(1), 1–23.

Facione, P. A. (2015). Permission to Reprint for Non-Commercial Uses Critical Thinking: What It Is and Why It Counts. Insight Assessment, 5(1), 1–30.

Fadhilah, M., & Nuriza, K. I. (2025). Efektivitas Pembelajaran Berbasis AI dan Augmented Reality dalam Meningkatkan Literasi Digital dan Fungsi Eksekutif Otak Siswa SD: Tinjauan Literatur Sistematis. GHANCARAN: Jurnal Pendidikan Bahasa Dan Sastra Indonesia, 881–897.

Faidah, S., Nafiah, N., Ibrahim, M., & Akhwani, A. (2022). Peningkatan kemampuan berpikir kritis siswa sekolah dasar melalui model pembelajaran problem posing. Jurnal Basicedu, 6(3), 3213–3221.

Farwati, E., Sari, N., & Hasanah, N. (2025). Analisis Media Pembelajaran Ipas Pada Materi Listrik Statis Dan Dinamis Bagi Siswa Sekolah Dasar. JURNAL ILMIAH NUSANTARA, 2(5), 1189–1196.

Fitriani, H. (2024). The Relationship of Literacy Skills to the Misconception of Science Teaching for Madrasah Ibtidaiyah Teacher Candidates. Science Education Research (Search) Journal, 3(1). https://e-jurnal.iainsorong.ac.id/index.php/jaser%0A

Ghifari, M., & Ash, A. (2025). Fenomena Brain Rot Dalam Perspektif Hadis: Analisis Dampaknya Terhadap Moralitas Remaja. Al-Bayan: Jurnal Ilmu Al-Qur'an Dan Hadist, 8(2), 276–293.

Handayani, K. (2024). Strategi adaptif untuk mempertahankan tenaga kerja di era society 5.0: Menghadapi tantangan cobot. Jurnal Penelitian Multidisiplin Bangsa, 1(3), 185–200.

Herlambang, Y. T. (2021). Pedagogik: Telaah kritis ilmu pendidikan dalam multiperspektif. Bumi Aksara.

Herlambang, Y. T., & Abidin, Y. (2023). Pendidikan Indonesia dalam

menyongsong dunia Metaverse: Telaah filosofis semesta digital dalam perspektif pedagogik futuristik. Naturalistic: Jurnal Kajian dan Penelitian Pendidikan dan Pembelajaran, 7(2), 1630-1640.

Huda, R. B. (2025). Penguatan Pendidikan Karakter Melalui Kurikulum Merdeka Dengan Program Profil Pelajar Pancasila. Journal Education, Sociology and Law, 1(1), 34–46.

Julianto, I. R. (2024). Pentingnya Inovasi Pembelajaran Puisi dengan Menggunakan Ragam Media pada Tingkat Sekolah Dasar. Elementary Journal: Jurnal Pendidikan Guru Sekolah Dasar, 7(2), 264–274.

Juwairiah, J., Lubis, M. S. A., Rizki, M. Y., Aminuddin, R., Darwata, S. R., & Zainudin, M. (2025). Peran Augmented Reality (AR) dalam Meningkatkan Pemahaman Konsep Sains Siswa. Indonesian Research Journal on Education, 5(4), 602–608.

Kartini, K. S., Labasariyani, N. L. P., Abenk, M. I. S., & Putra, I. N. T. A. (2025). Efektivitas Game Edukasi Berbasis Augmented Reality Untuk Meningkatkan Pemahaman Konsep Struktur Tumbuhan Pada Siswa Sekolah Dasar 8 Jimbaran. Jurnal Informatika Dan Teknik Elektro Terapan, 13(3).

Komarudin, A. (2025). Integrasi Augmented Reality dalam Pembelajaran Matematika: Tinjauan Teoretis Pendekatan Kognitif dan Visualisasi Spasial. Jurnal Axioma: Jurnal Matematika Dan Pembelajaran, 10(2), 26–36.

Kusum, J. W., Akbar, M. R., & Fitrah, M. (2023). Dimensi Media Pembelajaran (Teori dan Penerapan Media Pembelajaran Pada Era Revolusi Industri 4.0 Menuju Era Society 5.0). PT. Sonpedia Publishing Indonesia.

Lokollo, L. J., Lasaiba, M., Arfa, A. M., & Lasaiba, D. (2024). Mengembangkan kemampuan berpikir spasial melalui pendidikan STEM di sekolah dasar: Developing spatial thinking abilities through STEM education in elementary schools. Scholaria: Jurnal Pendidikan Dan Kebudayaan, 14(3), 293–308.

Marinda, L. (2020). Teori perkembangan kognitif Jean Piaget dan problematikanya pada anak usia sekolah dasar. An-Nisa': Journal of Gender Studies, 13(1), 116–152.

Martir, L., Sayangan, Y. V., & Beku, V. Y. (2024). Penerapan Model Pembelajaran Discovery Learning dalam Meningkatkan Kemampuan Berpikir Kritis Siswa Sekolah Dasar pada Pembelajaran IPAS. In JURNAL PENDIDIKAN MIPA (Vol. 14, Issue 3, pp. 757–766). STKIP Taman Siswa Bima. https://doi.org/10.37630/jpm.v14i3.1829

Masrur, I., & Maghfirah, N. I. (2025). Strategi dan Media Pembelajaran Dalam Implementasi Pendekatan Deep Learning. Jurnal Al-Fatih, 8(2), 760–781.

Mifroh, N. (2020). Teori perkembangan kognitif Jean Piaget dan implementasinya dalam pembelajaran di SD/MI. JPT: Jurnal Pendidikan Tematik, 1(3), 253–263.

Naila Nafaul Faiza, I. S. W. (2024). Media Pembelajaran Abad 21 : Membangun Generasi. Jurnal Media Akademik (Jma), 2(12), 2–14.

Nainggolan, A. M., & Daeli, A. (2021). Analisis teori perkembangan kognitif Jean Piaget dan implikasinya bagi pembelajaran. Journal of Psychology Humanlight, 2(1), 31–47.

Oktafiani, R., & Haka, N. (2024). The Impact of The Jurisprudential Analytical Inquiry Learning Model Assisted by Augmented Reality (Assemblr Edu) on Critical Thinking Abilities in Biology For 10th Grade High School Students. International Journal Education and Computer Studies (IJECS), 4(1), 1–9.

Patmaniar, P., Jumarniati, J., Hardiana, H., Taufiq, T., & Baharuddin, M. R. (2024). Pengembangan Modul Ajar Digital Berbasis Augmented Reality Terintegrasi Profil Pelajar Pancasila. Jurnal Riset Dan Inovasi Pembelajaran, 4(3), 2056–2071.

Pebriyanti, M., & Siagian, F. N. (2024). Kesiapan Guru dalam Penilaian Autentik pada Kurikulum Merdeka Pembelajaran IPAS

di Sekolah Dasar. IBTIDA', 5(1), 1–10.

Permana, B. S., Hazizah, L. A., & Herlambang, Y. T. (2024). Teknologi pendidikan: efektivitas penggunaan media pembelajaran berbasis teknologi di era digitalisasi. Khatulistiwa: Jurnal Pendidikan Dan Sosial Humaniora, 4(1), 19-28.

Prayogi, R. D. (2020). Kecakapan abad 21: Kompetensi digital pendidik masa depan. Manajemen Pendidikan, 14(2).

Purwono, F. H., Ulya, A. U., Purnasari, N., & Juniatmoko, R. (2019). Metodologi Penelitian (Kuantitatif, Kualitatif dan Mix Method). Guepedia.

Puspita, D., Wardana, L. A., Hattarina, S., & Prastiwi, R. (2025). Pengembangan Media Diorama Materi Fotosintesis Berbasis Ar Meningkatkan Pemahaman Berfikir Kritis Siswa Dalam Pembelajaran IPAS Kelas IV DI SDN PILANG 1. Journal Educational Research and Development| E-ISSN: 3063-9158, 1(3), 351–363.

Putri, N. F., & Azzizah, D. K. (2025). Analisis Kemampuan Berfikir Kritis Dan Kreatif Siswa Melalui Strategi Pembelajasan Berbasis Diskusi Di Mata Pelajaran Pkn Di SD Kelas IV. Menulis: Jurnal Penelitian Nusantara, 1(5), 442–447.

Rahim, A. (2023). Meningkatkan keterampilan berpikir kritis melalui pembelajaran kritis. Journal Sains and Education, 1(3), 80–87.

Rahmanda, R. (2025). Efektivitas Pembelajaran Berbantuan Augmented Reality Terhadap Peningkatan Kemampuan Berpikir Kritis Siswa Sekolah Dasar. Bima Journal of Elementary Education, 3(2), 73–84.

Rakhman, P. A., Salsyabila, A., Nuramalia, N., & Gustiani, P. E. (2024). Meningkatkan motivasi belajar siswa di SDN Cilampang melalui media pembelajaran digital dan konvensional. Jurnal Inovasi Pembelajaran Di Sekolah, 5(2), 615–622.

Ramadhani, N., Ulya, W. J., Nustradamus, S. B., Fakhriyah, F., & Ismaya, E. A. (2023). Sistematic literature riview: peran media pembelajaran interaktif dan konvensional pada proses pembelajaran di sekolah dasar. Student Scientific Creativity Journal, 1(5), 99–114.

Reffiane, F., Agustini, F., Nuvitalia, D., & Saputra, H. J. (2025). Sains dalam Genggaman: Eksplorasi Media Literasi Sains yang Menyenangkan. Penerbit NEM.

Saepudin, A., & Wulandari, F. (2023). Pemanfaatan Augmented Reality (AR) Dalam Pembelajaran Sains Di Sekolah Dasar. Jurnal Primary Edu, 1(3), 355–367.

Sartini, S., Chondro, A., Prayitno, H. J., & Chairunissa, I. (2024). Tantangan kepemimpinan adaptif dalam dunia pendidikan di era generasi milenial. TEACHING: Jurnal Inovasi Keguruan Dan Ilmu Pendidikan, 4(2), 98–110.

Setiawan, B., Winarno, A., Iasha, V., & Barokah, A. (2025). Virtual Reality dalam Pembelajaran Sains. PT. Pena Persada Kerta Utama.

Somantri, D., & Komala Putri, S. (2023). Persepsi Guru terhadap Integrasi TPACK dalam Pembelajaran IPS di Sekolah Dasar. JURNAL SADEWA: PUBLIKASI ILMU PENDIDIKAN, PEMBELAJARAN DAN ILMU SOSIAL Учредители: Asosiasi Riset Ilmu Manajemen Dan Bisnis Indonesia, 2(1), 89–102.

Sugiyono, P. D. (2010). Metode penelitian kuantitatif dan kualitatif. Bandung: CV Alfabeta.

Sulianta, F. (2025). Masyarakat digital: Tren, tantangan, dan perubahan di era teknologi. Feri Sulianta.

Suryaman, M., & Ningsih, S. (2025). Model Pembelajaran Berbasis Digital Dengan Menggunakan Aplikasi Puzzel Marker Meningkatkan Hasil Belajar Siswa SMAN 1 Cikarang Pusat. Jurnal Tahsinia, 6(11), 1727–1738.

Susanto, A. H., & Wulandari, M. D. (2024). Optimalisasi Pembelajaran Anak Usia Sekolah Dasar Melalui Pemahaman Teori Perkembangan Kognitif Jean Piaget. Pendas: Jurnal Ilmiah Pendidikan Dasar, 9(04), 689–706.

Tarigan, R. B. (2025). Pemanfaatan Augmented Reality (AR) dalam Pembelajaran IPA untuk Menumbuhkan Pemahaman Konsep Sistem Tata Surya di Sekolah Dasar. Jurnal Ilmiah Multidisiplin

Mahasiswa Dan Akademisi, 1(1), 1–12.

Viqri, D., Gesta, L., Rozi, M. F., Syafitri, A., Falah, A. M., Khoirunnisa, K., & Risdalina, R. (2024). Problematika Pembelajaran IPAS dalam Kurikulum Merdeka. Jurnal Inovasi, Evaluasi Dan Pengembangan Pembelajaran (JIEPP), 4(2), 310–315.

Wahid, R., & Asrina, N. J. (2024). Workshop Revitalisasi Peran Orang Tua dalam Mendidik Generasi Alpha. Jurnal Pengabdian Kepada Masyarakat Abdi Putra, 4(3), 198-203.

Wahid, R., Nurihsan, J., & Nuryani, P. (2023). Kajian Pedagogik Tentang Pendidikan Multikultural Pada Materi PPKn Untuk Meningkatkan Nasionalisme Siswa. Naturalistic: Jurnal Kajian dan Penelitian Pendidikan dan Pembelajaran, 7(2), 1519-1525.

Wiguna, I. W. D. P., & Sudarti, N. W. (2024). Peran literasi digital dalam penguatan profil pelajar Pancasila dimensi mandiri, bernalar kritis, dan kreatif. International Journal of Multilingual Education and Applied Linguistics, 1(3), 42–52.

Wijayati, I. W. (2024). Efektivitas Media Augmented Reality (AR) Berbasis Kearifan Lokal terhadap Peningkatan Literasi Sosial Siswa Sekolah Dasar. Jurnal Jendela Pendidikan, 4(04), 487–509.

Yunansah, H., Yuniarti, Y., Herlambang, Y. T., Wahid, R., & Hendriyani, A. (2022). Rancang bangun media bahan ajar digital berbasis multimodalality dalam pendekatan pedagogik futuristik. Naturalistic: Jurnal Kajian dan Penelitian Pendidikan dan Pembelajaran, 6(2), 1136-1149.

Zaky, M., Jarnawi, M., Pahriadi, P., & Tadeko, N. (2024). Penggunaan Media Augmented Reality Berbasis Kearifan Lokal Bapidok Baku bagi Guru di SMP Kecamatan Balantak dalam Upaya Memperkuat Literasi. Journal Of Human And Education (JAHE), 4(5), 930–940.

.

.