ijolii

Indonesian Journal Of Learning and Instructional Innovation
Volume 4, Issue 01 (2026), pp. 54-61 | e-ISSN: 3025-8316
https://journal.uns.ac.id/ijolii | https://doi.org/10.20961/ijolii.v4i01.3590

The Effect of Web-Based Game Media (Earthgames) on Critical Thinking Skills in Earth Structure Learning for Junior High School Students

Lewi Damar Oktavian[1], Eka Budhi Santosa[2], Fatma Sukmawati[3], Cinta Kasih Putri Thomas[4]
[1,2,3] Educational Technology, Universitas Sebelas Maret, Surakarta, Indonesia
[4] Educational Technology, Universitas Negeri Yogyakarta, Sleman, Indonesia
E-mail: [1]lewidamar10@student.uns.ac.id*, [2]ekabudhisantosa@staff.uns.ac.id,
[3]fatmasukmawati@staff.uns.ac.id, [4]cintakasih.2022@student.uny.ac.id
*Corresponding Author

Article History: Received: May 13, 2026; Accepted: June 26, 2026; Published: June 30, 2026

ABSTRACT

This study investigates the effect of web-based game media, specifically Earthgames supported by the Wordwall platform, on the critical thinking skills of eighth-grade students in the topic of Earth Structure in the Natural Sciences (IPA) subject. A pre-experimental design using a one- group pretest-posttest approach was employed, involving 64 students from SMP Negeri 27 Surakarta during the 2025/2026 academic year. Data were collected through validated critical thinking tests covering indicators of interpretation, analysis, evaluation, inference, explanation, and problem-solving based on Facione's framework. Results showed a significant improvement in students' mean scores from 45.57 (pretest) to 67.27 (posttest). The hypothesis test using the Paired Sample t-test (Sig. < 0.001) confirmed a statistically significant difference, with an N- Gain score of 0.43 (moderate category). These findings indicate that Earthgames via Wordwall positively influenced students' critical thinking by providing interactive, visual, and game-based learning experiences. The media supports Mayer's Cognitive Theory of Multimedia Learning and aligns with the constructivist principles underpinning 21st-century science education.

Keywords: *Critical Thinking, Earthgames, Earth Structure, Science Learning, Web-based Game Media*

INTRODUCTION

Facing the era of globalization and 21st-century technological advancement, education systems are increasingly required to develop higher-order thinking competencies, particularly critical thinking skills (Calma et al., 2025; OECD, 2020). Critical thinking enables students to not merely receive information passively but to analyze, interpret, evaluate arguments, and make logical decisions amid complex modern challenges (Calma et al., 2025). International educational organizations such as the OECD (2020) in the PISA framework and UNESCO (2016) in its Global Education Monitoring Report explicitly identify critical thinking as one of the 4Cs (Critical thinking, Creativity, Communication, Collaboration) that must be integrated into 21st-century learning. In Indonesia, PISA 2022 ranked the country 74th out of 79 nations in scientific literacy, reflecting persistent weaknesses in analytical and evaluative reasoning (OECD, 2022). This gap between 21st-century competency demands and actual IPA learning outcomes in Indonesia has been extensively documented (Kemdikbud, 2022).

In the theoretical context of science education, Facione (2021) defines critical thinking as a cognitive process involving interpretation, analysis, evaluation, inference, explanation, and self-regulation. Through these skills, students can interpret scientific data, evaluate hypotheses, formulate evidence-based arguments, and draw systematic conclusions. However, national assessment data shows that the competency of junior high school students in Indonesia is generally still at a basic level (Rahayu & Sugianto, 2021). This challenge is exacerbated by the fact that technological and information developments have drastically changed the landscape of learning media. Multimedia is no longer simply text and sound, but has evolved into a comprehensive combination of text, graphics, animations, images, and even audio/video, which have a tremendous impact on students' knowledge reconstruction (Setyaningsih, 2023). If these dynamic changes are not balanced with creative teaching variations, the classroom learning process will become monotonous, triggering boredom, and reducing student participation and motivation (Arifin et al., 2025). Therefore, the application of cutting-edge technological innovations, including the potential use of three-dimensional virtual spaces such as the metaverse, is now starting to be seen as a future trend to provide immersive and natural learning experiences in various educational institutions (Alhakimi, 2023).

At the classroom level, critical thinking development is hampered by teacher-centered instruction. Teachers remain the sole source of information while students passively receive knowledge (Paul, 2020). The reliance on static textbooks and worksheets further limits exploration, discussion, and problem-solving opportunities (Chen, 2024). This challenge is especially acute in IPA learning, where concepts require visualization, experimentation, and higher-level reasoning (Nugraha, 2023). Real-world conditions often demonstrate poor student understanding of science material due to unvaried and boring conventional teaching methods, which ultimately lead to passive and stifled students (Fitriani & Ridhani, 2025). However, the integration of digital technology, such as the use of cloud computing (Google Forms, Quizizz, and Wordwall), has been shown to significantly improve the efficiency, effectiveness, and quality of learning outcomes (Purnama et al., 2024).

The urgent need for well-designed interactive media has become a crucial focus in educational technology. The development of multimodal and adaptive digital learning media requires a solid foundation of instructional design models, such as the Dick & Carey Model, to ensure the media produced is valid, engaging, increases engagement, and effectively supports creative thinking and problem-solving (Yasni et al., 2025). Furthermore, systematically managing digital science learning using a clear instructional framework has been shown to be more effective in supporting students' higher-level cognitive processes than simply transmitting raw content (Sasongko et al., 2025).

To create an immersive, challenging, and meaningful learning environment, Game-Based Learning (GBL) has emerged as a highly promising innovative approach. Characteristics of GBL include clear goals and rules, scaffolded difficulty levels, real-time interactivity and feedback, and realistic contextual simulations (Mao et al., 2021; Wardani et al., 2023). A meta-analysis by Mao et al. (2021) confirmed that gamification significantly improved critical thinking skills (mean Hedges' g effect ≈ 0.7). Fatih et al. (2024) also demonstrated that digital educational games stimulate reflective analysis and evaluation in science learning. The use of GBL, such as serious games and VR simulations that integrate structured development models (e.g., ADDIE), has been shown to effectively increase motivation, engagement, and problem-solving skills (Raziana & Wibawanto, 2025).

One web-based interactive platform that facilitates this approach is Wordwall, which offers a variety of game formats such as quizzes, matching games, and crosswords that are easily adapted to various subject areas. Empirical research confirms that using Wordwall improves student engagement and cognitive outcomes in science (Saputra, 2021; Kurniawan, 2022). Based on this principle, this study developed Earthgames, a thematic game designed within the

Wordwall platform specifically for the Earth Structure topic, aligned with Facione's (2015) critical thinking indicators. Theoretically, this medium refers to Mayer's (2021) Cognitive Theory of Multimedia Learning, which states that learning is more effective when information is presented through visual and verbal channels simultaneously (the dual-channel principle), accompanied by appropriate cognitive load management (limited capacity) and active processing by learners. Through a combination of animation, graphics, and text-based interactive challenges, Earthgames helps students organize and internalize the Earth Structure concept more deeply.

Preliminary observations at SMP Negeri 27 Surakarta revealed that critical thinking skills among Grade VIII students remained low, with 62% experiencing difficulty explaining logical reasons, 54% struggling to analyze cause-effect relationships, and 65% lacking confidence in presenting systematic arguments. These findings underscore the urgent need for innovative, technology-based instructional media. While previous studies have widely explored the general use of web-based tools, there is still a significant research gap in how systematically designed, multimedia-theory-based educational games like Earthgames on Wordwall can directly impact all components of Facione's critical thinking indicators within abstract geoscientific topics. This research therefore aims to determine the effect of using Earthgames via Wordwall on the critical thinking skills of eighth-grade students at SMP Negeri 27 Surakarta in the IPA Earth Structure topic.

METHODS

Research Design

This study employed a quantitative approach using a pre-experimental one-group pretest-posttest design. This design was selected to measure changes in critical thinking skills within the same group of participants before and after the Earthgames intervention, providing empirical evidence of the media's effect (Creswell, 2020).

Participants

Participants were 64 eighth-grade students (Classes VIII A and VIII E) from SMP Negeri 27 Surakarta in the 2025/2026 academic year. Purposive sampling was applied based on criteria: prior exposure to Earth Structure content without digital interactive media, teacher-confirmed low critical thinking levels, and adequate device readiness for web-based media use.

Procedure

The study was conducted over four sessions: (1) Pretest administration; (2) Introduction and initial use of Earthgames via Wordwall; (3) Reinforcement of Earth Structure concepts through continued Earthgames activities; (4) Posttest administration. Students accessed the game through personal devices (smartphones or laptops) and engaged in quizzes, image-analysis tasks, and Earth Structure-based conceptual challenges.

Data Analysis

Descriptive statistics (mean, standard deviation) were computed for pretest and posttest scores. A normality test (Kolmogorov-Smirnov) confirmed normal data distribution (Sig. = 0.172 > 0.05), enabling the use of a Paired Sample t-test ($\alpha = 0.05$) for hypothesis testing. N-Gain analysis was conducted to assess the magnitude of improvement.

RESULTS AND DISCUSSION

Results

1. Pre-test results

The pretest mean score was 45.57 (SD = 12.74), with a minimum of 27.78 and a maximum of 66.67. The majority of students (37.5%) scored in the 31–40 interval, indicating that critical thinking skills were predominantly at a low-to-moderate level prior to the intervention.

Table 1. Pre-test Descriptive Statistics

No.	Statistic	Value
1	N	64
2	Highest Score	66.67
3	Lowest Score	27.78
4	Mean	45.57
5	Median	44.44
6	Std. Deviation	12.74

2. Post-test results

Following the Earthgames intervention, the mean posttest score increased to 67.27 (SD = 16.11), with a minimum of 38.89 and a maximum of 100. The majority of students (28.13%) scored in the 61–70 interval, reflecting a notable upward shift in performance distribution.

Table 2. Post-test Descriptive Statistics

No.	Statistic	Value
1	N	64
2	Highest Score	100
3	Lowest Score	38.89
4	Mean	67.27
5	Median	66.67
6	Std. Deviation	16.11

3. Nomality test results

The Kolmogorov-Smirnov normality test yielded a significance value of 0.172 (> 0.05), confirming that the data were normally distributed. The Monte Carlo Sig. value of 0.102 further corroborated this finding, validating the use of parametric statistical analysis.

4. Hypothesis Testing (Paired Sample t-test)

The Paired Sample t-test revealed a significance value of Sig. (2-tailed) < 0.001, which is well below the threshold of $\alpha = 0.05$. Consequently, H_o was rejected and H_1 was accepted, confirming a statistically significant difference between pretest and posttest scores. This result indicates that the use of Earthgames via Wordwall had a significant effect on students' critical thinking skills.

Table 3. Paired Sample t-test Results

Variable	Mean Pre-test	Mean Post-test	Sig.	Decision
Pretest–Posttest	45.57	67.27	<0.001	H_o Rejected

4. N-Gain analysis results

The N-Gain value was calculated at 0.43 (43.03%), placing the improvement in the moderate category ($0.3 \leq g \leq 0.7$). This indicates that the Earthgames intervention contributed meaningfully to critical thinking development, though further refinement of instructional strategies and extended implementation periods could yield higher gains.

Discussion

The significant increase in critical thinking scores following Earthgames intervention supports the theoretical foundations of game-based learning and multimedia instruction. The mean improvement from 45.57 to 67.27 reflects gains across all Facione critical thinking indicators, particularly interpretation, analysis, evaluation, and inference.

These findings are consistent with prior research. Mao et al. (2021) found that gamification produces a substantial effect on critical thinking development (Hedges' g ≈ 0.7). Similarly, Fatih et al. (2024) demonstrated that digital educational games for IPA significantly improved students' analytical and evaluative reasoning through reflective challenge-based learning. This finding is also in line with a study by Raziana & Wibawanto (2025) which confirmed that pedagogical innovation in the form of Game-Based Learning (GBL) which utilizes interactive game elements in authentic scenarios can significantly increase students' motivation, active engagement, and 21st-century skills such as logical thinking and problem-solving. This increase in cognitive performance proves that a dynamic and meaningful learning atmosphere can be created effectively when teachers creatively combine appropriate methods, media, and interactions to overcome student learning boredom in the classroom (Arifin et al., 2025).

The Wordwall platform, with its immediate feedback mechanisms and adaptive difficulty levels, enabled students to engage actively in Earth Structure concepts that are otherwise abstract and difficult to visualize. The success of the intervention using the Wordwall component in Earthgames reinforces the research findings of Purnama et al. (2024) regarding the effectiveness of utilizing cloud-based technology (cloud computing), which has been proven to have a real positive impact on learning efficiency and the quality of students' academic outcomes. This transformation of the learning process from conventional to interactive media has proven to be a crucial solution to classroom problems often encountered in science learning, where a direct learning model assisted by varied visual media is able to boost student learning completion in a classical manner compared to monotonous teacher teaching methods (Fitriani & Ridhani, 2025).

In alignment with Mayer's (2021) Cognitive Theory of Multimedia Learning, the dual-channel processing enabled by Earthgames—combining visual animations with text-based questions— facilitated deeper conceptual understanding. Students were not merely passive recipients of content but were required to analyze geoscientific phenomena, make predictions, and justify their reasoning, all of which are core components of critical thinking. The holistic nature of contemporary digital multimedia, which integrates text, graphics, animation, and audio/video, has been proven to have a significant impact on helping students independently reconstruct their knowledge across various educational institutions (Setyaningsih, 2023). Through dynamic visualization, the barriers to abstraction in complex geoscience material can be optimally reduced.

The learning outcomes achieved in this study are also inseparable from the systematic design of instructional management. As stated by Sasongko et al. (2025), the integration of digital platforms developed using formal instructional design models (such as the Dick and Carey model) significantly contributes to supporting students' higher-level cognitive processes, where structured digital learning management has been shown to be superior to simply transmitting content one-way. The validity and effectiveness of this visual game-based media are also supported by Yasni et al.'s (2025) argument that systematically developed multimodal digital media based on multimedia theory can support creative thinking processes and in-depth student learning engagement, making it highly relevant to the needs of 21st-century learning.

From a constructivist perspective, the interactive nature of Earthgames supported Vygotsky's (1978) social learning principles through scaffolded challenges and collaborative discussion. Students reported greater ease in connecting theoretical concepts—such as tectonic plate movement and seismic activity—with real-world phenomena after using the media, indicating meaningful learning experiences. This interactivity provides cognitive stimulation similar to the future vision of the use of immersive technologies such as the metaverse, where 3D digital spaces that blend the real and virtual worlds are projected to be able to provide new, natural and intuitive opportunities for global educational needs (Alhakimi, 2023).

The moderate N-Gain (0.43) is notable in the context of a relatively short intervention (four sessions) and a single-group design without a control comparison. The absence of a control group limits causal inference, as observed improvements could partly reflect natural learning progression or test- retest effects. Nevertheless, the statistically significant pre-post differences and the alignment with established theoretical frameworks provide strong evidence of Earthgames' utility as a critical thinking- enhancing media.

Technical limitations were also observed: internet connectivity issues intermittently disrupted media access for some students, a challenge prevalent in school settings in Indonesia. Future implementations should account for offline backup options or local network solutions to ensure equitable access. The experience of technical constraints and variations in students' cognitive responses in this study indicate the need for further exploration of more measurable mentoring strategies (nuanced scaffolding), strengthening instrument validity, and optimizing digital learning management systems as metacognitive tools to measure students' cognitive regulation authentically in the long term (Buwono et al., 2025).

CONCLUSION

This study concludes that Earthgames, as a web-based educational game integrated within the Wordwall platform, serves as an effective instructional media to enhance junior high school students' critical thinking skills in learning science, specifically on the topic of Earth Structure. The interactive, visual, and gamified features of the media provide an immersive learning experience that successfully stimulates core dimensions of critical thinking, including interpretation, analysis, evaluation, and inference. By transforming abstract geoscientific concepts into manageable cognitive challenges, the media minimizes conceptual barriers and shifts the classroom environment from passive absorption to active logical reasoning.

The theoretical and practical value of Earthgames directly aligns with Mayer’s Cognitive Theory of Multimedia Learning and Facione's critical thinking framework, demonstrating that well-structured digital game-based learning supports 21st-century science competencies. Future educational implementations should expand this approach by employing experimental designs with control groups to isolate causal progress, extending the digital game formats across broader scientific themes and diverse grade levels, and adopting qualitative or performance-based evaluation instruments to fully map the deep, non-formal dimensions of students' reflective reasoning development.

CONFLICT OF INTEREST

The authors have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

REFERENCES

Alhakimi, H. (2023). Development of the Metaverse and learning. *Indonesian Journal of Learning and Instructional Innovation*, 1(01), 12-15. https://doi.org/10.20961/ijolii.v1i01.918

Angelelli, C. V., Giachero, M., & Odetti, L. (2023). Serious games and critical thinking development. *Frontiers in Psychology*, 14, 10279556.

Arifin, S., Pratama, M. B., Jaini, Agustiawati, D., Amelya, Z., & Nashriya, F. S. (2025). Unveiling the Creative Teacher’s Secret: A Systematic Review of Learning Variations for Active Classrooms. *Indonesian Journal of Learning and Instructional Innovation*, 3(02), 64-72. https://doi.org/10.20961/ijolii.v3i2.2366

Buwono, F. A., Djono, Bashir, N. L., & Putri, C. N. (2025). Computational Thinking-Based Metacognitive Learning Assessment: Issues and Challenges. *Indonesian Journal of Learning and Instructional Innovation*, 3(02), 102-118. https://doi.org/10.20961/ijolii.v3i2.2991

Calma, A., & Davies, M. (2025). Assessing students' critical thinking abilities via a systematic evaluation of essays. *Studies in Higher Education*, 1–16.

Chen, Z., S., J., & Wang, L. (2024). Static instructional media and its limitations in fostering critical thinking. *Thinking Skills and Creativity*, 42, 100963.

Creswell, J. W. (2020). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). SAGE Publications.

Facione, P. A. (2015). *Critical Thinking: What It Is and Why It Counts*. Insight Assessment.

Facione, P. A. (2021). *Critical Thinking: What It Is and Why It Counts* (updated ed.). Insight Assessment.

Fatih, A., Oktavia, F., & Andayani, M. (2024). Game-based digital learning and critical thinking in IPA. *Jurnal Inovasi Pendidikan Sains*, 10(1), 35–42.

Fitriani, I. N., & Ridhani, J. (2025). Effectiveness of Student Learning Outcomes Through Numbered Head Together Method Theme of Changes in The Appearance of The Earth and Sky. *Indonesian Journal of Learning and Instructional Innovation*, 3(02), 54-63. https://doi.org/10.20961/ijolii.v3i2.1797

Hwang, G.-J. (2021). Effects of digital game-based learning on critical thinking in science education. *Educational Technology & Society*, 94–108.

Kemdikbud. (2022). *Kurikulum Merdeka dan Profil Pelajar Pancasila*. Kemendikbudristek.

Kurniawan, D., Prawira, Y. T., & Prasetya, R. D. (2022). Penggunaan Wordwall untuk meningkatkan kemampuan analisis peserta didik pada pelajaran IPA SMP. *Jurnal Pendidikan Sains*, 77–85.

Lin, Y., Yu, W., Wang, L., & Xie, J. (2022). Learning analytics in digital platforms for critical thinking assessment. *Computers & Education*, 176, 104352.

Mao, W., Cui, Y., Chiu, M. M., & Lei, H. (2021). Effects of game-based learning on students' critical thinking: A meta-analysis. *Journal of Educational Computing Research*, 59(8), 1682–1708.

Mayer, R. E. (2021). *Multimedia Learning* (3rd ed.). Cambridge University Press.

Nugraha, D. A. (2023). Pembelajaran IPA berbasis inkuiri untuk mendorong penalaran ilmiah siswa SMP. *Jurnal Sains Edukasi*, 11(2), 55–62.

OECD. (2020). *PISA 2018 Results*. OECD Publishing.

OECD. (2022). *PISA 2022 Science Results*. OECD Publishing.

Paul, R., & Elder, L. (2020). *The Miniature Guide to Critical Thinking Concepts and Tools* (8th ed.). Foundation for Critical Thinking.

Purnama, B. R. C., Liantoni, F., & Maryanti. (2024). Pemanfaatan Teknologi Cloud Computing dalam Pembelajaran Informatika di SMK. *Indonesian Journal of Learning and Instructional Innovation*, 2(01), 88-95. https://doi.org/10.20961/ijolii.v2i01.1306

Rahayu, N., & Sugianto, H. (2021). Analisis kemampuan berpikir kritis peserta didik SMP. *Jurnal Pendidikan Indonesia*, 10(1), 123–132.

Raziana, E., & Wibawanto, H. (2025). Pedagogical Innovation of Game-Based Learning for 21st Century Skills in Vocational Education: A Systematic Literature Review. *Indonesian Journal of Learning and Instructional Innovation*, 3(01), 19-30. https://doi.org/10.20961/ijolii.v3i1.2494

Saputra, D. A., & Saputra, N. (2021). Penerapan media Wordwall dalam meningkatkan hasil belajar IPA di sekolah menengah pertama. *Jurnal Inovasi Pendidikan IPA*, 12–19.

Saputra, D. A., & Nugroho, R. (2025). Game-based learning berbasis Wordwall dalam pembelajaran sains. *Jurnal Teknologi Pendidikan*, 27(1), 12–20.

Sasongko, E. J., Djono, Solihah, K. R., Putri, M. C. H., & Muiz, A. (2025). Developing a Digital Learning Management Strategy Using the Dick and Carey Model to Enhance Junior High School Students' Critical Thinking in Biology Learning. *Indonesian Journal of Learning and Instructional Innovation*, 3(02), 140-147. https://doi.org/10.20961/ijolii.v3i02.3008

Setyaningsih, E. (2023). Perkembangan Multimedia Digital dan Pembelajaran. *Indonesian Journal of Learning and Instructional Innovation*, 1(01), 24-34. https://doi.org/10.20961/ijolii.v1i01.920

Sung, Y. T., Lin, C. H., & Lee, C. L. (2022). The effects of game-based learning on critical thinking. *Computers & Education*, 180, 104456.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Wahyuni, S., et al. (2021). Kendala abstraksi konsep IPA dalam pembelajaran struktur bumi. *Jurnal Sains Edukasi*, 9(3), 188–195.

Wardani, S., Arini, L., & Susanti, S. (2023). Pengembangan board game untuk pembelajaran kimia dan peningkatan critical thinking. *JPII*, 12(2), 112–123.

Yasni, Z., Djono, Maulidina, R. C. W., Santoso, F. A., & Agustin, I. W. (2025). Development of Flipbook-Based Learning Media Using the Dick & Carey Model and Its Impact on Elementary School Students' Creative Problem-Solving Skills. *Indonesian Journal of Learning and Instructional Innovation*, 3(02), 119-129. https://doi.org/10.20961/ijolii.v3i2.2998

Zhou, M., Wang, X., & Luo, L. (2023). Integrating multimedia theory and game design to foster critical thinking in science education. *Journal of Educational Computing Research*, 61(2), 345–369.