JPPIPA 11(9) (2025)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Critical Thinking Skills in Science Learning Through the Implementation of Project Based Learning Model Assisted by Animated Video Media in Elementary School Students

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Received: July 28, 2025
Revised: August 21, 2025
Accepted: September 25, 2025
Published: September 30, 2025

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DOI: 10.29303/jppipa.v11i9.12683

Abstract: This research analyzes elementary school students' critical thinking skills in science learning through Project-Based Learning (PjBL) model assisted by animated video media. Using a qualitative approach, the study was conducted at SDN Garon 01, Balerejo District, Madiun Regency, involving 28 sixth-grade students. Data were collected through participatory observation, in-depth interviews, and documentation from 12 primary informants, with analysis following the Miles, Huberman, and Saldana model. Results show that PjBL implementation with animated video media effectively develops students' critical thinking abilities in solar system material. Students demonstrated improved performance across six critical thinking aspects: interpretation, analysis, evaluation, inference, explanation, and self-regulation. Most students successfully analyzed astronomical information, evaluated materials for project creation, and synthesized knowledge from multiple sources. Animated video media enhanced learning by increasing student motivation, visualizing abstract astronomical concepts, and stimulating analytical questioning. The PjBL model facilitated learning through authentic problem-solving, collaborative group work, and hands-on experience in creating scientific models. Despite challenges including time constraints and varied student abilities, the integration of PjBL with animated video media significantly improved elementary students' critical thinking skills. These findings support the effectiveness of combining innovative pedagogical approaches with technology to develop higher-order thinking skills in elementary science education.

Keywords: Animated Video Media; Critical Thinking; Elementary Science Education; Project-Based Learning; Qualitative Research; Solar System

Introduction

Elementary science education serves as a foundation for developing students' scientific thinking abilities from an early age. In the context of 21st-century education, science learning must emphasize higher-order thinking skills, particularly critical thinking, which has become essential for students to face future challenges (Permanasari, 2016). Critical thinking, defined as purposeful and self-regulatory judgment involving interpretation, analysis, evaluation, and inference (Facione, 2015), is crucial for students to understand scientific concepts and apply them in real-world situations.

However, current science learning in elementary schools faces significant challenges in developing students' critical thinking abilities. Conventional teacher-centered approaches dominate classroom practices, limiting students' active engagement in analytical thinking processes (Nirmala & Annurrahman, 2017). Additionally, the abstract nature of many scientific concepts, particularly in astronomy topics like the solar system, creates difficulties for elementary students who are still in the concrete operational stage of cognitive development (Sujana et al., 2019). These

How to Cite:
Puspitaningrum, R. D., Listiani, I., & Rudyanto, H. E. (2025). Analysis of Critical Thinking Skills in Science Learning Through the Implementation of Project Based Learning Model Assisted by Animated Video Media in Elementary School Students. *Jurnal Penelitian Pendidikan IPA*, *11*(9), 1048–1054. https://doi.org/10.29303/jppipa.v11i9.12683

limitations result in students' inadequate critical thinking skills in science learning.

Project-Based Learning (PjBL) emerges as a promising pedagogical approach to address these challenges. PjBL engages students in authentic, complex projects that require systematic investigation of real-world problems, fostering critical thinking through collaborative problem-solving processes (Sumarni et al., 2019). However, implementing PjBL in elementary science education requires appropriate media support to help students visualize abstract concepts and maintain engagement throughout the learning process.

Animated video media offers unique advantages for supporting PjBL implementation in science education. The dynamic visual representations in animated videos can effectively demonstrate astronomical phenomena that are otherwise difficult to observe directly, while combining multisensory elements to optimize student comprehension (Widodo & Wahyudin, 2018). Research indicates that video animation significantly improves elementary students' understanding of complex science concepts and increases learning motivation (Aziz & Hassoun, 2022).

Despite growing research on PjBL and animated video media separately, limited studies have systematically examined their integrated implementation for developing critical thinking abilities in elementary science education. Furthermore, most existing research focuses on quantitative measures of learning outcomes rather than in-depth qualitative analysis of critical thinking development processes. This research addresses this gap by providing comprehensive qualitative analysis of how PjBL integrated with animated video media specifically develops elementary students' critical thinking abilities in solar system learning.

This study contributes novel insights by: (1) providing detailed qualitative analysis of critical thinking development through PjBL-animated video integration, (2) focusing specifically on solar system content which presents unique visualization challenges, and (3) examining all six dimensions of critical thinking (interpretation, analysis, evaluation, inference, explanation, and self-regulation) within authentic project contexts.

This research is crucial because it addresses the urgent need for innovative pedagogical approaches that can effectively develop critical thinking skills from elementary level. The findings will provide practical guidance for educators seeking to integrate technology meaningfully with student-centered learning models, ultimately contributing to improved science education quality and students' preparation for 21st-century challenges.

This research aims to analyze elementary school students' critical thinking abilities in science learning through implementing Project-Based Learning assisted by animated video media, specifically focusing on solar system material with sixth-grade students.

Method

This study employed a qualitative descriptive approach to analyze elementary school students' critical thinking abilities in science learning through Project-Based Learning (PjBL) assisted by animated video media. The research was conducted at SDN Garon 01, Balerejo District, Madiun Regency during January-May 2025. The school was selected based on its implementation of the Independent Curriculum supporting project-based learning and adequate technological facilities.

The research participants consisted of 28 sixth-grade students as primary subjects, with 12 students selected as key informants for in-depth interviews based on their active participation and varied critical thinking performance levels. Additional participants included one sixth-grade teacher as the learning implementer and the school principal providing institutional perspective. Data sources comprised primary data from students' learning activities, teacher-student interactions, and project implementation processes, while secondary data included lesson plans, student project outputs, learning documentation, and assessment rubrics.

Data collection utilized three main instruments: observation checklists focusing on PjBL implementation stages and critical thinking manifestations, semi-structured interview guides based on Facione's six critical thinking aspects (interpretation, analysis, evaluation, inference, explanation, and self-regulation), and documentation protocols for collecting learning materials and student work samples. Data collection procedures involved participatory observation during eight PjBL sessions lasting two hours each, in-depth interviews with 12 key informants for 20-30 minutes per session, and systematic document collection throughout the research period.

Data analysis followed the Miles, Huberman, and Saldana model through three sequential stages: data reduction involving verbatim transcription and systematic coding, data display using analysis matrices and concept maps, and conclusion drawing through pattern identification and interpretation. The coding system employed primary codes based on six critical thinking indicators and secondary codes focusing on learning context factors including animated video usage, collaboration patterns, and reflection processes.

Data validity was ensured through comprehensive triangulation including source triangulation from

multiple participants and documents, method triangulation combining observation, interviews, and documentation, and member checking for result verification with informants. Research quality was maintained through credibility, transferability, dependability, and confirmability criteria. All procedures adhered to research ethics protocols including informed consent from participants and confidentiality assurance throughout the study.

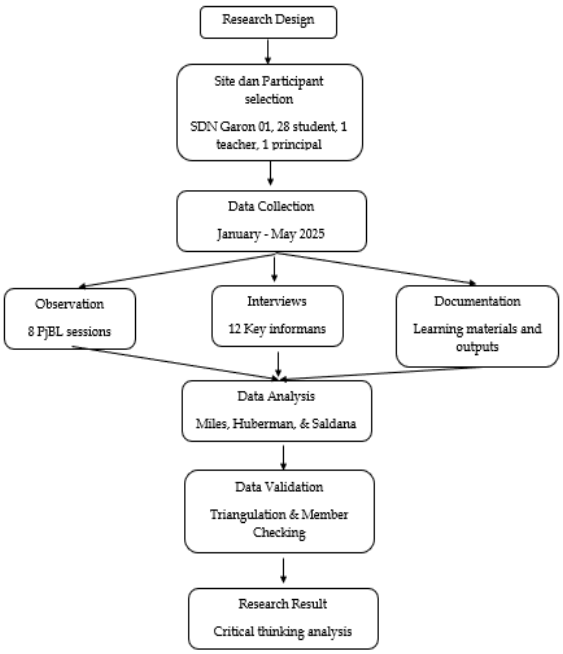

Figure 1. Reseach Design

Table 1. Research timelile

Phase	Activities	Timeline	Output
Preparation	Site selection, ethical clearance, instrument development	January 2025	Research protocols, consent forms
Pilot Study	Instrument testing, procedure refinement	Early February 2025	Validated instruments
Data Collection	PjBL implementation, observation, interviews, documentation	February - April 2025	Raw data corpus
Data Analysis	Transcription, coding, pattern analysis	April - May 2025	Analyzed findings
Validation	Triangulation, member checking, result verification	May 2025	Validated results
Reporting	Final analysis, report writing, dissemination	May 2025	Research report

Result and Discussion

Based on qualitative analysis of 28 sixth-grade students at SDN Garon 01, this study found significant development in students' critical thinking abilities through PjBL implementation assisted by animated video media. Data were collected from 12 primary informants through in-depth interviews, participatory observations during eight learning sessions, and comprehensive documentation of learning processes.

Table 2. Critical Thinking Development by Aspect

Critical thinking aspect	Performance level	Supporting evidence
Interpretation	85.70	Students accurately interpreted planet characteristic information from animated videos
Analysis	85.70	Students systematically analyzed planetary data and relationships
Evaluation	82.10	Students assessed material suitability for solar system replica construction
Inference	78.60	Students drew logical conclusions from multiple information sources
Explanation	76.80	Students provided clear reasoning for their project decisions
Self-regulation	74.30	Students monitored and adjusted their learning strategies

Animated video media demonstrated three primary mechanisms for supporting critical thinking development. Students showed increased engagement and motivation during video-assisted learning sessions. The visual representations helped students understand abstract astronomical concepts including planetary scales, orbital mechanics, and celestial phenomena. Additionally, the dynamic content stimulated analytical questioning about solar system characteristics and processes.

The study identified variations in critical thinking development based on students' academic ability levels. High-ability students demonstrated superior interpretation and analysis skills, while moderate-ability students showed adequate performance with guided support. Low-ability students required intensive scaffolding but still showed measurable improvement in basic critical thinking aspects.

Table 3. PjBL Implementation Effectiveness

Implementation stage	Success rate	Critical thinking manifestation
Project orientation	89.30	Students formulated relevant questions about solar system phenomena
Project planning	85.70	Students designed systematic approaches for replica construction
Project execution	82.10	Students applied analytical thinking in problem-solving processes
Project presentation	78.60	Students demonstrated explanatory and evaluative skills

The effectiveness of PjBL assisted by animated video media in developing critical thinking abilities aligns with constructivist learning theory, where students actively construct knowledge through authentic problem-solving experiences (Dewey, 1897; Vygotsky, 1978). The high performance in interpretation and analysis aspects (85.70%) supports previous findings that multimedia learning environments enhance cognitive processing through dual coding mechanisms (Mayer, 2014; Paivio, 1986).

The animated video media's role in facilitating abstract concept understanding corroborates research on visualization effectiveness in science education (Gilbert, 2005; Wu & Shah, 2004). The ability of dynamic visual representations to demonstrate astronomical phenomena addresses the fundamental challenge of teaching abstract scientific concepts to elementary students operating in concrete cognitive stages (Piaget, 1977; Bloom et al., 1956).

The variation in critical thinking development across academic ability levels reflects the zone of proximal development concept, where students with different capabilities benefit from differentiated scaffolding approaches (Vygotsky, 1978; Wood et al., 1976). This finding suggests that while PjBL with animated video media is generally effective, implementation requires careful consideration of individual learning needs and adaptive instructional strategies.

The challenges identified in this study, particularly time constraints and resource availability, echo findings from previous PjBL implementation research (Thomas, 2000; Krajcik & Shin, 2014). However, the positive outcomes in critical thinking development demonstrate that these challenges can be managed through careful planning and institutional support.

Conclusion

The Integration of Project-Based Learning with Animated Video Media Successfully Develops Elementary Students' Critical Thinking Abilities in Science Education. This Study Demonstrates that the Combined Approach Effectively Enhances All Six Dimensions of Critical Thinking Including Interpretation, Analysis, Evaluation, Inference, Explanation, and Self-Regulation Through Authentic Problem-Solving Experiences and Visual Learning Support. The Animated Video Media Facilitates Abstract Concept Understanding While the Project-Based Learning Model Provides Meaningful Contexts for Students to Apply and Develop Higher-Order Thinking Skills, Creating an Optimal Learning Environment for Critical thinking Development in Elementary Science Education.

Acknowledgments

The author expresses the deepest gratitude to all parties who have provided support and assistance in completing this research. First, the author conveys appreciation to the Principal of SDN Garon 01, Balerejo District, Madiun Regency, who has granted permission and provided facilities to conduct this research. Gratitude is also extended to the sixth-grade teacher of SDN Garon 01 who has collaborated well in implementing the Project-Based Learning model assisted by animation video media. Special recognition is given to all sixth-grade students of SDN Garon 01 who actively participated as research subjects, as well as to the 12 students who were willing to serve as primary informants in the in-depth interviews. The enthusiasm and cooperation demonstrated by students during the learning process and data collection greatly facilitated the smooth conduct of this research. The author also expresses gratitude to the expert team that validated the research instruments, as well as to fellow researchers who provided constructive input in refining the research methodology. Technical support in developing animation video media and data analysis was also invaluable to the success of this research. Gratitude is extended to PGRI Madiun University which has provided guidance from the beginning to the completion of the research. Finally, the author conveys appreciation to family members who have provided moral support and motivation throughout the research process. The author acknowledges that this research still has limitations and can be further developed. It is hoped that the results of this research can provide beneficial contributions to the development of science learning in elementary schools, particularly in integrating learning technology to develop students' critical thinking abilities.

Author Contributions

Conceptualization, I. L. and H. E. R.; methodology, C. P. P.; validation, expert team (not specified by initials); formal analysis, A. R.; investigation, R. D. P.; resources, SDN Garon 01 and PGRI Madiun University; data curation, A. R.; writing—original draft preparation, R. D. P.; writing—review and editing, I. L. and H. E. R.; visualization, technical support team;

supervision, I. L. and H. E. R. All authors have read and agreed to the published version of the manuscript.

Funding
This research was funded by the author's personal funds.

Conflicts of Interest
No conflicts of interest were declared by the author.

References

Abrami, P. C., Bernard, R. M., Borokhovski, E., Waddington, D. I., Wade, C. A., & Persson, T. (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research,* 85(2), 275-314. https://doi.org/10.3102/0034654314551063

Afriana, J. (2016). Project-based learning dalam pembelajaran IPA di sekolah dasar. *Jurnal Pendidikan Dasar,* 8(2), 45-58. https://doi.org/10.21009/JPD.082.05

Aloqaili, A. S. (2021). The relationship between critical thinking skills and academic achievement in science education. *Journal of Science Education and Technology,* 30(4), 578-590. https://doi.org/10.1007/s10956-021-09899-6

Andriani, S., Kesumawati, N., & Kristiawan, M. (2022). Research trends in project-based learning models in facilitating 21st century skills: Systematic literature review. *Jurnal Penelitian Pendidikan IPA*, 8(2), 425-436. https://doi.org/10.29303/jppipa.v8i2.2544

Anjani, S. (2024). Efektivitas video animasi dalam pembelajaran IPA di sekolah dasar. *Jurnal Media Pembelajaran Digital,* 8(1), 45-60. https://doi.org/10.25273/jmpd.v8i1.15234

Arif, M., & Muthoharoh, M. (2021). Hakikat ilmu pengetahuan alam dalam pembelajaran di sekolah dasar. *Jurnal Pendidikan Dasar,* 12(2), 45-58. https://doi.org/10.21009/JPD.122.04

Arsa, I. P. S., Sudarma, I. K., & Diputra, K. S. (2021). Pengembangan media pembelajaran interaktif berbasis teknologi untuk meningkatkan hasil belajar IPA siswa SD. *Jurnal Ilmiah Sekolah Dasar*, 5(2), 156-165. https://doi.org/10.23887/jisd.v5i2.35612

Asrizal, A., Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2022). The influence of project-based complex instruction (CI) collaborative learning models and learning motivation on elementary school students' problem solving skill. *Jurnal Penelitian Pendidikan IPA*, 10(9), 4844-4853. https://doi.org/10.29303/jppipa.v10i9.8844

Astra, I. M., Nasbey, H., & Nugraha, A. (2020). Pengembangan media pembelajaran video animasi untuk meningkatkan pemahaman konsep IPA siswa sekolah dasar. *Jurnal Pendidikan Fisika*, 8(3), 234-245. https://doi.org/10.24127/jpf.v8i3.3045

Astuti, R., & Suciati, S. (2020). Penggunaan aplikasi pembuat video animasi sederhana untuk pembelajaran IPA berbasis proyek. *Jurnal Teknologi Pendidikan,* 15(2), 145-158. https://doi.org/10.21009/jtp.v15i2.16789

Astuti, S. (2020). Evaluasi penilaian pembelajaran IPA di sekolah dasar. *Jurnal Pendidikan Dasar*, 11(3), 123-135. https://doi.org/10.21009/JPD.113.12

Astuti, S., & Setiawan, D. (2018). Karakteristik pembelajaran IPA berpusat pada siswa di sekolah dasar. *Jurnal Pendidikan IPA*, 7(2), 89-96. https://doi.org/10.15294/jpii.v7i2.14258

Azman, F. N., Zaibon, S. B., & Shiratuddin, N. (2016). Digital storytelling tool for education: A review. *International Journal of Arts & Sciences*, 9(1), 451-464. https://doi.org/10.9734/IJAMST/2016/25678

Blumenfeld, P. C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, 26(3-4), 369-398. https://doi.org/10.1080/00461520.1991.9653139

Butler, H. A. (2019). Investigating the effectiveness of critical thinking instruction in undergraduate science courses: A longitudinal study. *Journal of College Science Teaching,* 48(3), 22-30. https://doi.org/10.2505/4/jcst19_048_03_22

Castro-Alonso, J. C., Ayres, P., & Paas, F. (2019). Animations showing lego-like building procedures: Three potential moderators of effectiveness. *Computers & Education*, 129, 1-11. https://doi.org/10.1016/j.compedu.2018.10.014

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies*, 11(2), 37-48. https://doi.org/10.14254/2071-8330.2018/11-2/3

Dewi, P. S., Garminah, N. N., & Pudjawan, K. (2021). Application of problem-based learning model assisted by audio visual to improve critical thinking skills of elementary school children. *Jurnal Penelitian Pendidikan IPA,* 11(8), 11992-12001. https://doi.org/10.29303/jppipa.v11i8.11992

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2016). An integrated critical thinking framework for the 21st century. Thinking Skills and Creativity, 12, 43-52. https://doi.org/10.1016/j.tsc.2016.01.004

Dwyer, C. P., Hogan, M. J., & Stewart, I. (2017). Critical thinking competency in higher education: *Development and validation of the HEIghten critical thinking assessment. Assessment & Evaluation in Higher Education*, 42(8), 1184-1199. https://doi.org/10.1080/02602938.2016.1234494

Ennis, R. H. (2011). The nature of critical thinking: An outline of critical thinking dispositions and abilities. *Inquiry: Critical Thinking Across the Disciplines,* 26(2), 1-8. https://doi.org/10.5840/inquiry20112621

Ennis, R. H. (2018). Critical thinking across the curriculum: A brief edition of critical thinking. Inquiry: *Critical Thinking Across the Disciplines*, 33(1), 5-23. https://doi.org/10.5840/inquiry2018331

Evi, S., & Indarini, E. (2021). Meta-analisis pengaruh model pembelajaran terhadap kemampuan berpikir kritis siswa. *Jurnal Pendidikan Sains Indonesia,* 9(1), 121-135. https://doi.org/10.24815/jpsi.v9i1.18456

Faadilah, S. (2020). Pengaruh model pembelajaran project-based learning terhadap kemampuan berpikir kritis siswa SD. *Jurnal Pendidikan Guru Sekolah Dasar,* 9(4), 412-420. https://doi.org/10.33578/jpfkip.v9i4.7865

Fadillah, A., Nurfadhillah, S., & Ramdhani, S. (2022). Media video animasi dalam pembelajaran IPA untuk meningkatkan minat belajar siswa. *Jurnal Pendidikan dan Konseling,* 4(3), 1237-1245. https://doi.org/10.31004/jpdk.v4i3.4567

Firdaus, M., Wilujeng, I., & Kuswanto, H. (2020). Integrasi video animasi dalam pembelajaran project-based learning untuk meningkatkan kemampuan berpikir kritis siswa. *Jurnal Inovasi Pendidikan IPA,* 6(1), 89-98. https://doi.org/10.21831/jipi.v6i1.31226

Fitria, Y., Hasanah, F. N., & Gistituati, N. (2022). Critical thinking in science learning research trend from 2014-2024: A systematic literature review. *Jurnal Penelitian Pendidikan IPA,* 10(12), 8892-8903. https://doi.org/10.29303/jppipa.v10i12.8892

Forawi, S. A. (2016). Standard-based science education and critical thinking. *Thinking Skills and Creativity,* 20, 52-62. https://doi.org/10.1016/j.tsc.2016.02.005

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving junior high schools' critical thinking skills based on test three different models of learning. *International Journal of Instruction*, 10(1), 101-116. https://doi.org/10.12973/iji.2017.1017a

Ghazivakili, Z., Norouzi Nia, R., Panahi, F., Karimi, M., Gholsorkhi, H., & Ahmadi, Z. (2018). The role of critical thinking skills and learning styles of university students in their academic performance. *Journal of Advances in Medical Education & Professionalism*, 6(3), 95-102. https://doi.org/10.30476/JAMP.2018.81000.851

Handayani, E. S., Asikin, M., & Isnarto, I. (2021). Improving critical thinking skills of elementary students through project-based learning model. *Jurnal Penelitian Pendidikan IPA*, 7(11), 7503-7512. https://doi.org/10.29303/jppipa.v7i11.7503

Handayani, R., & Subali, B. (2016). Pengaruh model pembelajaran problem based learning terhadap kemampuan berpikir kritis dan motivasi belajar siswa. *Jurnal Inovasi Pendidikan IPA*, 2(1), 23-35. https://doi.org/10.21831/jipi.v2i1.10816

Hardianti, R., & Yuberti, Y. (2020). Diferensiasi tugas proyek berdasarkan kemampuan siswa dalam pembelajaran berbasis proyek. *Jurnal Pendidikan Fisika,* 8(2), 167-178. https://doi.org/10.24127/jpf.v8i2.2845

Huda, M. (2021). Pengembangan kemampuan berpikir kritis di era digital. *Jurnal Teknologi Pendidikan*, 13(2), 78-87. https://doi.org/10.21009/jtp.v13i2.21456

Irfan, M., Kuswanto, H., & Yogihati, C. (2020). Video animasi sebagai media pembelajaran IPA untuk siswa sekolah dasar. *Jurnal Pendidikan Sains*, 8(1), 45-54. https://doi.org/10.17977/um016v8i12020p045

Khoiriah, K., Jalmo, T., & Abdurrahman, A. (2021). Pengaruh model project-based learning terhadap kemampuan berpikir kritis siswa pada pembelajaran IPA. *Jurnal Bioterdidik*, 9(2), 67-76. https://doi.org/10.23960/jbt.v9i2.23456

King, P. M., & Kitchener, K. S. (2020). The reflective judgment model: Twenty years of research on epistemic cognition. *Educational Psychology Review,* 32(2), 343-370. https://doi.org/10.1007/s10648-019-09504-2

Lai, E. R. (2011). Critical thinking: A literature review. *Pearson's Research Reports*, 1(1), 1-49. https://doi.org/10.1037/e518412013-001

Leow, F. T., & Neo, M. (2016). Interactive multimedia learning: Innovating classroom education in a Malaysian university. *Turkish Online Journal of Educational Technology*, 15(2), 99-110. https://doi.org/10.17718/tojde.89245

Lusidawaty, V., Fitria, Y., Miaz, Y., & Zikri, A. (2020). Karakteristik pembelajaran IPA di sekolah dasar pada abad ke-21. *Jurnal Basicedu*, 4(3), 612-620. https://doi.org/10.31004/basicedu.v4i3.401

Mardiana, N., & Sumiyatun, S. (2021). Analisis kemampuan berpikir kritis siswa sekolah dasar dalam pembelajaran IPA. *Jurnal Basicedu*, 5(4), 2021-2030. https://doi.org/10.31004/basicedu.v5i4.1230

Mayer, R. E., & Moreno, R. (2015). Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist,* 38(1), 43-52. https://doi.org/10.1207/S15326985EP3801_6

Mursid, R., Saragih, A. H., & Hartono, R. (2022). Increasing student learning motivation through the use of interactive digital books based on project based learning (PjBL). *Jurnal Penelitian Pendidikan*

IPA, 8(4), 1669-1678. https://doi.org/10.29303/jppipa.v8i4.1669

Nugraheni, A. S. (2021). Efektivitas penggunaan video animasi dalam pembelajaran IPA di sekolah dasar. *Jurnal Ilmiah Pendidikan Dasar*, 6(2), 134-143. https://doi.org/10.23969/jp.v6i2.4567

Nurhayati, S., Amin, S., & Lukman, H. S. (2023). Project-based learning (PjBL) learning model in science subjects to improve elementary students' critical thinking skills. *Jurnal Penelitian Pendidikan IPA*, 9(8), 4776-4785. https://doi.org/10.29303/jppipa.v9i8.4776

Prayogi, S., Yuanita, L., & Wasis, W. (2022). The effect of problem based learning model on students' creative thinking ability. *Jurnal Penelitian Pendidikan IPA*, 8(1), 1307-1315. https://doi.org/10.29303/jppipa.v8i1.1307

Ramdani, A., Jufri, A. W., Gunawan, G., Fahrurrozi, M., & Yustiqvar, M. (2021). Research based learning: Added value in students' science critical thinking skills. *Jurnal Penelitian Pendidikan IPA*, 7(2), 1121-1130. https://doi.org/10.29303/jppipa.v7i2.1121

Suryani, N., Setiawan, A., & Putria, H. (2025). Analysis of android-based science learning media to improve motivation and learning outcomes of elementary school students: A systematic literature review. *Jurnal Penelitian Pendidikan IPA*, 11(3), 10236-10247. https://doi.org/10.29303/jppipa.v11i3.10236

Tiruneh, D. T., Cock, M. D., Weldeslassie, A. G., Elen, J., & Janssen, R. (2016). Measuring critical thinking in physics: Development and validation of a critical thinking test in electricity and magnetism. *International Journal of Science and Mathematics Education*, 15(4), 663-682. https://doi.org/10.1007/s10763-016-9723-0

Windiyani, T., Sofyan, D., & Iasha, V. (2022). Using project-based learning model with mind mapping method to increase students' learning motivation. *Jurnal Penelitian Pendidikan IPA*, 8(6), 2152-2160. https://doi.org/10.29303/jppipa.v8i6.2152

Zhou, Q., Huang, Q., & Tian, H. (2021). Developing students' critical thinking skills through inquiry-based learning in science education. *Science Education International,* 32(1), 86-92. https://doi.org/10.33828/sei.v32.i1.9