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Elementary Students' Perceptions of Creative Learning Through Food Chain Diorama Projects: A Case Study

Laila Diah Ayu Pratiwi*
Universitas Negeri Semarang, Indonesia

Nuni Widiarti
Universitas Negeri Semarang, Indonesia

Agus Yuwono
Universitas Negeri Semarang, Indonesia

***Corresponding Author:** lailapratiwi006@students.unnes.ac.id

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Abstract
This study investigates elementary students' perceptions of the implementation of project-based learning through the Food Chain Diorama (DIONTANA) model in science education, with a focus on its contribution to creativity development. Employing a qualitative case study design, the research involved 30 fifth-grade students from SD Negeri 5 Metro Selatan who engaged in the DIONTANA project. Data were collected through observations, semi-structured interviews, and documentation, and analyzed using Miles and Huberman's interactive model. The findings indicate that the DIONTANA project fostered student creativity across four Torrance dimensions—fluency, flexibility, originality, and elaboration—while enhancing conceptual understanding and collaborative skills. Three-dimensional dioramas served as cognitive bridges, transforming abstract ecological concepts into concrete representations. Students reported high levels of motivation and engagement, supported by autonomy, competence, and social interaction. However, challenges such as time constraints, limited material access, and individual learning differences emerged. The study suggests adaptive strategies including flexible timelines, resource banks, differentiated mentoring, and school-community partnerships. These findings highlight the pedagogical value of integrating contextual, collaborative, and creativity-centered approaches in elementary science curricula to promote 21st-century competencies.

INTRODUCTION

Elementary education represents a critical phase in the development of children aged 6 to 12 years, during which a gradual transition occurs from concrete to abstract thinking. Recent studies emphasize that cognitive development at this stage is influenced by a variety of factors, including early biological conditions and the diversity of learning stimuli in the environment (Rapuc et al., 2025; Park et al., 2025). In line with Piaget's theory, children at this stage are in the concrete operational phase, characterized by their ability to understand symbols and simple logical relationships, although they are not yet fully capable of systematically handling abstract concepts (Oogarah-Pratap et al., 2025; Fitriani & Zaini, 2025). Piaget's framework remains relevant in explaining children's cognitive dynamics, particularly in the development of technology-based curricula (Cerovac & Keane, 2025), special education (Tosolini et al., 2025), and moral and value formation (Meifang, 2025).

In today's increasingly complex and dynamic global landscape, creative thinking skills have emerged as a key 21st-century competency that must be cultivated from an early age. These skills are not only essential for supporting problem-solving and innovation but also serve as a foundation for higher-order thinking that is adaptable to change and relevant across life domains (Paz-Baruch et al., 2025; Citraningtyas et al., 2022). Creative thinking involves unique cognitive processes—such as primary process thinking—that enable imagination, free association, and novel idea integration in problem-solving contexts (Suler, 1980). Accordingly, educational approaches in elementary schools should be purposefully designed to nurture children's creative potential from an early stage (Rodd,

1999; Agusta, 2020). Science learning is recognized as a natural context for fostering such skills, as it involves integral processes of exploration, experimentation, and reflection (Maslin et al., 2025; Sitorus, 2016). Within this context, design-based approaches such as *design thinking* are increasingly acknowledged for promoting creativity, collaboration, and open-ended thinking among young learners (Grönman et al., 2024). Moreover, recent systematic reviews suggest that although research on creative thinking in primary education is growing, there remains a need to strengthen empirical and applied strategies within instructional contexts (Smare & Elfatihi, 2023). Consequently, there is a pressing need for pedagogical breakthroughs that are not only conceptual in nature but also contextualized and measurable in developing elementary students' creative thinking.

Fostering creative thinking through science education is essential for building meaningful conceptual understanding while enhancing students' cognitive and affective engagement (Yang et al., 2016; Waldrip & Prain, 2017). Research shows that creative thinking in science can be facilitated through instructional strategies that encourage idea exploration, problem-solving, and connections to real-life experiences (Newton & Newton, 2010; Wijaya et al., 2014). However, science instruction in Indonesian elementary schools remains predominantly conventional, focusing on rote memorization and one-way information delivery, which limits students' creative development and science process skills (Rustaman et al., 2018). In this regard, *Project-Based Learning* (PjBL) has proven to be an effective pedagogical approach in promoting active, collaborative, and meaningful learning (Kaldi et al., 2011; Chu et al., 2011; Tascı, 2015). PjBL implementation not only improves conceptual understanding and information literacy but also fosters positive attitudes toward science and teamwork skills. Furthermore, integrating PjBL with STEM-oriented and authentic contexts—such as robotics or architectural design projects—has shown potential in strengthening higher-order thinking and 21st-century skills (Karahoca et al., 2011; Krajcik et al., 2023; Rustaman et al., 2018). Therefore, adopting PjBL at the elementary level becomes a strategic move in realizing science learning that is creative, transformative, and responsive to contemporary educational needs.

Several studies further demonstrate that the effectiveness of PjBL can be enhanced through the use of contextual media, such as dioramas. As a three-dimensional visual medium, dioramas allow students to concretely represent abstract scientific concepts—such as food chains—in observable and tangible ways (Humaira & Ninawati, 2023; Putra, 2022). Such visual representations not only bridge the gap between conceptual understanding and everyday experiences but also play a significant role in cognitive development through deep and imaginative visualization processes (Mnguni, 2014; Uttal & Doherty, 2008). Recent findings underscore that integrating project-based media into science education enhances not only conceptual understanding but also creativity, emotional engagement, and problem-solving abilities (Azizah et al., 2020; Ferrero et al., 2021; Retno et al., 2025). Specifically, structured and contextual STEM-based PjBL approaches have been found effective in fostering critical, collaborative, and solution-oriented thinking skills in elementary students (Imaduddin et al., 2021; Rasyid et al., 2023). Thus, the integration of PjBL and dioramas represents not only a pedagogical innovation but also a transformative strategy for enhancing science learning that emphasizes creativity and meaningful understanding.

This study aims to explore in depth the perceptions of elementary school students regarding the contribution of the DIONTANA (Diorama of Food Chains) project-based learning model in fostering creative science learning. The primary focus is directed toward understanding how students perceive and reflect on their learning experiences during their involvement in the diorama-based PjBL activities. Additionally, the study seeks to identify the specific aspects of learning that students perceive as contributing to the development of creativity, such as their ability to visualize abstract concepts, collaborate with peers, and express scientific ideas imaginatively. Furthermore, the cognitive and affective engagement dynamics of students within the learning process that integrates contextual media like dioramas are of central interest. Through a qualitative approach and intrinsic case study design, this research is expected to provide a holistic and contextual understanding of how the

integration of PjBL and concrete visual media can serve as an effective pedagogical strategy to support the growth of students' creativity in elementary science education.

METHODS

This study employed a qualitative approach with an intrinsic case study design, aiming to explore in depth the perceptions of elementary school students regarding the contribution of the DIONTANA (Diorama of Food Chains) project-based learning model in fostering creative learning. A qualitative approach was deemed appropriate as it facilitates the investigation of participants' experiences and perspectives in a natural setting, allowing for a rich, descriptive understanding of the phenomenon under study (Creswell & Poth, 2016; Dodgson, 2017). Specifically, the intrinsic case study design enabled the researcher to focus on the particularities of the case in its real-life context, emphasizing the uniqueness and value of the case itself rather than generalization (Creswell & Poth, 2016). This design supports the exploration of the phenomenon in a contextual and holistic manner through direct interaction with participants. The population in this study consisted of 90 students at SD Negeri 5 Metro Selatan during the 2024/2025 academic year. The sample comprised 30 fifth-grade students selected purposively based on the following criteria: (1) having completed or currently undergoing science instruction on the topic of food chains, (2) direct involvement in the implementation of the DIONTANA project, and (3) diversity in academic background and project engagement to ensure data variation.

Data were collected using a triangulated approach through three primary techniques:

1. Non-interventionist participant observation, conducted across three project sessions. The researcher observed aspects such as student engagement, creative initiative, teamwork, and visual idea expression in the creation of dioramas. Observations were recorded using structured observation sheets and narrative field notes.
2. Semi-structured interviews, conducted with 12 selected students representing high, medium, and low engagement categories. Interview questions focused on students' perceptions of the learning process, encountered challenges, and their views on the relationship between the diorama project and creativity development (see Interview Guide, Appendix A). Each interview lasted between 20 and 30 minutes and was audio-recorded for transcription purposes.
3. Documentation, including (a) student group diorama products, (b) student reflective notes, (c) photographs of the project process, and (d) teacher observation records. These documents were analyzed as complementary data to support interpretation from observations and interviews.

Data analysis followed the interactive model of Miles and Huberman as cited in Makhin (2021), comprising four stages:

1. Data collection, involving the gathering of field data through observation, interviews, and documentation.
2. Data reduction, through selection, simplification, and transformation of raw data into initial codes representing elements of perception and creativity.
3. Data display, through organizing information into thematic matrices, narrative quotations, and visual summaries to identify inter-case patterns among students.
4. Conclusion drawing and verification, conducted iteratively by comparing findings across data sources and ensuring interpretations are grounded in empirical evidence.

To ensure qualitative validity and reliability, this study applied two forms of data trustworthiness procedures:

1. **Credibility**, ensured through several techniques, including:
   a. Method and source triangulation, involving a combination of observations, interviews, and documentation.
   b. Prolonged engagement, with the researcher present in each project session to understand natural dynamics.

c. Member checking, where interview summaries were confirmed with participants to avoid misinterpretation.
d. Document referencing, such as teacher creativity rubrics, used to verify consistency with field data.

2. **Confirmability**, ensured by:
   a. Develop an audit trail and document the data collection and analysis process.
   b. Researcher's reflective memos, used to examine potential biases and maintain interpretive objectivity.
   c. Ensuring that findings and interpretations were genuinely derived from the data, not from personal assumptions or preferences.

RESULTS AND DISCUSSION

Result

Students' Perceptions of the Implementation of Project-Based Learning "DIONTANA"

Data obtained from observations, interviews, and documentation revealed a range of student perceptions regarding implementing the DIONTANA (Food Chain Diorama) project-based learning model in science instruction. These perceptions reflect both cognitive and affective responses to the learning experience, and can be thematically categorized into four major dimensions:

1. Engagement in Learning – focusing on students' interest, motivation, and participation during the project.
2. Creativity Development – highlighting how students expressed fluency, flexibility, originality, and elaboration in designing the diorama.
3. Conceptual Understanding – addressing students' cognitive gains in comprehending abstract science concepts, particularly food chains.
4. Collaboration and Social Skills – reflecting interpersonal dynamics, teamwork, and communication during group work.

Engagement in Learning

87% of the 30 participating students (n = 26) expressed a high level of engagement during the implementation of the DIONTANA project. Data derived from interviews and observations consistently indicated that students found the project-based learning experience more interesting, meaningful, and enjoyable than conventional instructional methods. They described the learning process as interactive and personally relevant, with one student (R5) stating, *"I enjoyed learning science by making a food chain diorama. I could collaborate with my friends and felt like a real scientist researching the relationships among living organisms."* This qualitative evidence supports the notion that when students are provided with hands-on, authentic tasks situated in a meaningful context, their intrinsic motivation and engagement are enhanced.

However, the data also revealed variability in student experiences. Four students (13%) reported initial confusion and hesitation, primarily due to unfamiliarity with the project-based learning model. These students required additional guidance in understanding task expectations and coordinating group roles during the early implementation phases. This finding aligns with the understanding that students' engagement levels can vary based on prior exposure to student-centered learning approaches, and it highlights the importance of scaffolding and clear instructional support during the introduction of new pedagogical models.

Creativity Development

The findings of this study demonstrate that the implementation of the DIONTANA project contributed significantly to the development of students' creativity, as reflected in the four dimensions proposed by Torrance: fluency, flexibility, originality, and elaboration (Figure 2). Each dimension was explored through student reflections, observational field notes, and documentation of diorama outputs.

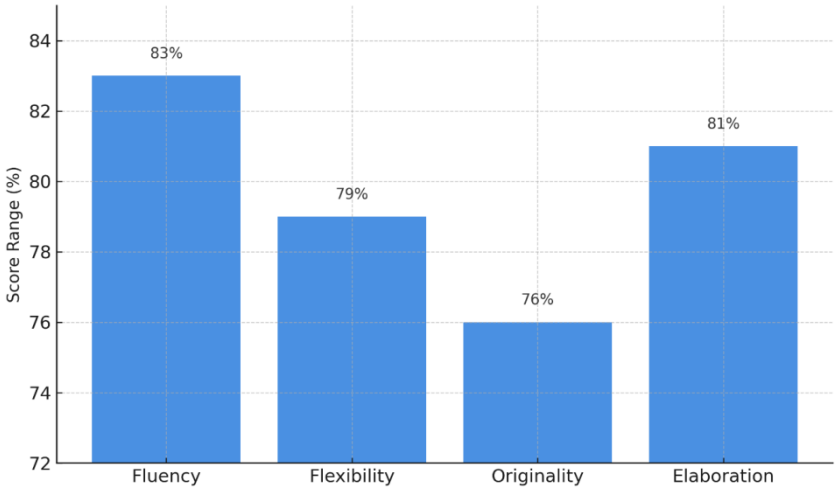

Figure 1. Data Creativity According to Torrance

The analysis revealed that the DIONTANA project significantly contributed to developing students' creativity across the four dimensions proposed by Torrance—fluency, flexibility, originality, and elaboration. In terms of fluency, 83% of students (n = 25) reported generating multiple ideas during the project, demonstrating divergent thinking through using various recycled materials such as dried leaves, plastic waste, and colored paper to build ecosystem elements. This abundance of ideation reflects the openness and flexibility of the project format, which encouraged free expression. Flexibility was observed in 79% of students (n = 24), who displayed the ability to shift perspectives by interpreting food chains not merely as linear relationships but as interconnected ecological systems, illustrating a more advanced, systemic understanding of biological interactions.

Originality was evident in the work of 76% of students (n = 23), who produced distinctive features in their dioramas—for instance, using transparent plastic to simulate river flow or textured materials to recreate realistic habitats—suggesting that the project created a psychologically safe space for creative experimentation. Furthermore, elaboration was demonstrated by 81% of students (n = 25), who enriched their projects with intricate details such as bark textures crafted from cardboard, nuanced leaf coloration to represent photosynthesis, and clearly labeled trophic roles, reflecting a high level of engagement and the ability to refine their creative output.

Nevertheless, 17% of students (n = 5) were identified as needing additional scaffolding, particularly during the planning and execution stages, indicating diverse levels of creative readiness within the group. These findings underscore the importance of differentiated instructional strategies to support all learners. From an educational psychology perspective, this aligns with Torrance's view of creativity as a multidimensional trait that can be cultivated through supportive, student-centered learning environments. The hands-on, visual-spatial nature of the DIONTANA project also resonates with constructivist learning theory, as students actively constructed knowledge through contextual, meaningful experiences that bridged abstract concepts with concrete representations.

Science Concept Understanding

A substantial majority of students (85%, n = 26) reported an improved understanding of the food chain concept following their participation in the DIONTANA project. Data obtained through semi-structured interviews and reinforced by observational field notes and student artifacts suggest that the use of three-dimensional dioramas served as an effective cognitive scaffold. Specifically, the physical and visual construction of ecosystems enabled students to concretize abstract ecological relationships, such as energy transfer and trophic levels, which are typically challenging to grasp at the elementary level.

This finding aligns with Piaget's theory of cognitive development, which places upper-elementary students within the concrete operational stage. At this stage, learners rely heavily on

tangible, visual, and experiential materials to construct meaning. The diorama project allowed students to manipulate and spatially organize representations of producers, consumers, and decomposers—thereby aligning instructional strategies with their developmental needs. One student (R15) explained: *"Previously, I was confused about how energy flows in a food chain. But after making the diorama, I could clearly see how producers, primary consumers, secondary consumers, and decomposers are interconnected."*

In addition to self-reported gains, student-created dioramas illustrated improved conceptual integration, as evidenced by the accurate sequencing of food chains, symbolic color use, and ecosystem structure. Observational data also noted increased use of disciplinary vocabulary (e.g., "decomposer," "herbivore," "energy flow") during group discussions, suggesting that the project facilitated both conceptual understanding and scientific literacy. These findings are consistent with the argument that visual-spatial learning tools, when embedded within active and collaborative frameworks like Project-Based Learning, can bridge the gap between abstract content and concrete understanding.

See Figure 1 for a visual summary of student responses on conceptual understanding and social skill development.

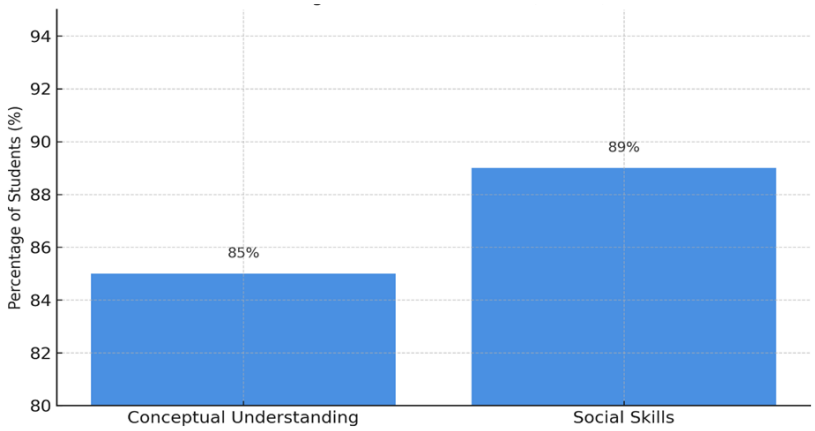

Figure 2. Conceptual Understanding and Social Skills Data

Collaboration and Social Skills

A majority of students (89%, n = 27) indicated that their collaboration and social skills improved as a result of participating in the DIONTANA project. Interview data and classroom observations consistently revealed that students were actively engaged in group-based tasks, such as discussing content ideas, assigning roles, negotiating design decisions, and resolving interpersonal disagreements. These collaborative interactions created a social learning environment that fostered the development of communication, empathy, and collective problem-solving.

One student (R21) stated, *"While working in groups, we had to discuss which animals and plants to include in the diorama. Sometimes we disagreed, but in the end, we were able to find a solution together."* This response highlights not only the cooperative dimension of the task but also students' ability to manage differing perspectives constructively—an essential component of 21st-century learning competencies.

Despite these positive outcomes, two students reported discomfort in group settings, citing that their ideas were often overlooked by more dominant peers. This finding suggests that although collaborative learning environments offer numerous benefits, they also require careful facilitation to ensure equitable participation. Teacher mediation and clearly defined group roles may be necessary to support students with lower confidence or assertiveness, particularly in diverse classrooms. From a pedagogical standpoint, the findings support the value of project-based learning in cultivating both cognitive and socio-emotional competencies. In line with Vygotsky's sociocultural theory, the social

context of learning—particularly peer interaction—serves as a critical mediating factor in students' development. The collaborative nature of the DIONTANA project enabled students to co-construct knowledge while simultaneously navigating and internalizing key social behaviors.

Challenges in the Implementation of the DIONTANA Project

Although students generally reported positive perceptions of the DIONTANA project, several challenges emerged during the implementation process. These challenges, identified through triangulated data from interviews, observations, and student reflections, highlight key areas that require pedagogical attention to optimize the effectiveness of project-based learning.

First, time constraints were reported by 35% of students (n = 10), who felt that the duration allocated for project completion was insufficient to fully develop and refine their ideas. Students expressed that while they were enthusiastic about the creative process, the limited time restricted their ability to explore alternative designs or make improvements based on peer or teacher feedback. Second, material availability was cited as a constraint by approximately 28% of students (n = 8). These students encountered difficulties in obtaining appropriate and sufficient materials for building their dioramas, such as miniature animal figures, textured natural items, or recycled components. This limitation affected both the execution quality and the expressive potential of their projects, especially for those aiming to create more elaborate or original representations. Third, individual differences in ability were noted through observation and corroborated by teacher documentation. About 18% of students (n = 5) required more intensive scaffolding to articulate and translate their creative ideas into physical models. These students demonstrated hesitation in decision-making and sought frequent guidance during each phase of the project, indicating a need for differentiated support strategies.

These findings reinforce the critical role of teachers in managing time effectively, ensuring equitable access to learning resources, and providing differentiated instruction tailored to individual learner needs. Without such support, the benefits of project-based learning may not be fully realized, particularly for students with varying levels of confidence, creativity, or familiarity with open-ended tasks. From a design-based implementation perspective, these challenges suggest that while project-based learning fosters autonomy and creativity, it also demands structured facilitation to address logistical and developmental diversity. Incorporating flexible timelines, curated material kits, and guided peer mentoring may serve as practical strategies to mitigate these issues in future applications.

Discussion

The findings of this study affirm that the implementation of the DIONTANA Project-Based Learning model significantly contributed to enhancing student engagement, creativity development, conceptual understanding in science, and collaborative skills. Broadly speaking, these results align with both constructivist and sociocultural educational theories that emphasize the importance of contextual, collaborative, and experiential learning environments. One of the key findings revealed that the majority of students experienced increased engagement throughout the project. This is consistent with prior research indicating that Project-Based Learning effectively enhances intrinsic motivation and active participation through authentic, collaborative, and meaningful learning tasks (Napitupulu & Murniarti, 2024; Stoica, 2024; Lam et al., 2009; Noor et al., 2024). Across various educational levels, from primary to higher education, PjBL has been shown to foster student responsibility (Johari & Bradshaw, 2008), leverage participatory technologies such as e-portfolios (Oh et al., 2020), and promote social interaction and real-world problem-solving (Ferreira & Canedo, 2020; Jeon et al., 2014). These findings thus reinforce empirical evidence suggesting that student engagement increases when they are immersed in socially structured and meaningful learning processes.

Nonetheless, it is important to note that a small number of students expressed initial confusion in understanding the project's workflow. This highlights the fact that implementing Project-Based Learning is not without challenges, particularly for students unfamiliar with open-ended pedagogical

approaches. As noted by Aldabbus (2018) and Đerić et al. (2021), the success of PjBL depends heavily on well-structured instructional design and proactive strategies to mitigate implementation barriers. In this regard, scaffolding plays a crucial role in helping students develop conceptual understanding and manage tasks incrementally (Aksela & Haatainen, 2019; Cintang et al., 2018). Jatisunda and Nahdi (2020) further emphasize that systematic scaffolding enhances students' problem-solving abilities in inquiry-based contexts—a principle equally applicable to PjBL, which requires active and autonomous cognitive engagement. Without such support, students risk becoming disoriented, as reported by Meyer et al. (1997) and Harris (2014), whose studies show that lack of initial guidance can impede motivation and strategy use. Therefore, adaptive and responsive pedagogical support is essential in facilitating the transition from traditional instruction to project-based models (Hussein, 2021).

Regarding creativity, the study revealed that the DIONTANA project successfully fostered students' creative expression, reflecting Torrance's (1966) four components of creativity: fluency, flexibility, originality, and elaboration. Most students demonstrated the ability to produce diverse visual representations of ecosystems using recycled materials, indicating a psychologically safe learning environment that encouraged creative exploration. These findings support the view that creativity is not a fixed trait but a dynamic potential that can be cultivated through learning environments that promote freedom of thought, exploration, and social support. This perspective aligns with the work of Treffinger (1995) and Dai (2020), who argue that creativity is part of a broader talent development process supported by adaptive educational strategies. In primary education, the teacher's role is central in shaping a classroom climate conducive to the realization of creative potential (Wintara & Dasar, 2017). Moreover, creativity is strongly influenced by spatial and cultural contexts, as noted by Meusburger (2009), who emphasizes the importance of "milieus of creativity" in shaping the conditions for creative expression. Dai (2015) also advocates for equitable and productive creative development, asserting that educational systems must balance academic achievement with opportunities for personal expression and talent realization.

Aligned with Piaget's theory of cognitive development, which places elementary students in the concrete operational stage, the DIONTANA project effectively supported students in visualizing the food chain concept more clearly. Constructing ecosystem components in three-dimensional form enabled learners to connect visual elements with ecological functions such as energy flow and trophic relationships. As one student (R15) stated, the project facilitated a cognitive transformation from confusion to comprehension through concrete modeling. This finding also reinforces previous studies suggesting that visual tools such as dioramas can function as effective cognitive scaffolds, especially in elementary science education. Visual representations not only aid in conceptual understanding but also strengthen the link between perceptual experience and scientific terminology. The frequent use of scientific vocabulary during group discussions in this study suggests improved conceptual literacy stimulated by visual processes. This aligns with the perspectives of de Jong (2006) and Flick (2000), who assert that visually and manipulatively-based scaffolds support structured scientific thinking. O'Donnell et al. (2002) similarly highlight the effectiveness of knowledge maps as cognitive scaffolds in processing complex information. Additionally, Rosenshine and Meister (1992) and Belland et al. (2013) emphasize that well-designed scaffolding not only promotes understanding but also enhances motivation and high-level learning strategies. Vogel et al.'s (2017) meta-analysis further confirms that socio-cognitive scaffolding, such as collaborative scripts, significantly strengthens learning outcomes in group-based settings, as reflected in the improved scientific interaction observed among students in this study.

Collaboration also emerged as a significant outcome of the project. Most students reported improvements in communication, empathy, and group decision-making skills. These outcomes illustrate the process of knowledge co-construction, as described in Vygotsky's sociocultural theory, where social interaction serves as a primary medium for both cognitive and social development. Although most students adapted well to collaborative work, some expressed that their ideas were not adequately heard. This underscores the importance of the teacher's role in ensuring equitable role

distribution and mediating interpersonal dynamics. Thus, Project-Based Learning requires a facilitative approach that not only focuses on the final product but also attends to the social processes embedded within collaborative learning experiences.

CONCLUSION

In summary, this study demonstrates that implementing the DIONTANA Project-Based Learning model significantly boosts student engagement, enhances creativity, improves understanding of scientific concepts, and strengthens collaborative skills in elementary science education. By integrating concrete visual tools such as dioramas and structured scaffolding, the model aligns with constructivist and sociocultural theories, effectively mediating abstract knowledge through experiential and social learning. Crucially, the findings underscore the need for deliberate instructional planning and early-stage support to prevent student disorientation, particularly for those unfamiliar with open-ended pedagogies. This reinforces the argument that cognitive scaffolding, social facilitation, and a psychologically supportive learning environment are essential components of successful PjBL integration. These insights contribute to the growing evidence base advocating for project-based approaches in primary education, suggesting that such models foster deeper learning and creative growth. Future research might explore the long-term impacts of PjBL on student achievement and the role of teacher development in sustaining high-quality implementation across diverse educational contexts.

REFERENCES

Agusta, A. R. (2020, December). The exploration study of teachers' knowledge and ability on application of critical thinking and creative thinking skills on learning process in elementary school. In *6th International Conference on Education and Technology (ICET 2020)* (pp. 29–42). Atlantis Press. https://doi.org/10.2991/assehr.k.201204.006

Aksela, M., & Haatainen, O. (2019). Project-based learning (PBL) in practise: Active teachers' views of its advantages and challenges. In *International STEM in Education Conference* (pp. 9–16). Queensland University of Technology. https://researchportal.helsinki.fi/files/121999663

Aldabbus, S. (2018). Project-based learning: Implementation & challenges. *International Journal of Education, Learning and Development*, *6*(3), 71–79. https://www.researchgate.net/publication/328368222

Azizah, W. A., Sarwi, S., & Ellianawati, E. (2020). Implementation of project-based learning model (PjBL) using STREAM-based approach in elementary schools. *Journal of Primary Education*, *9*(3), 238–247. https://journal.unnes.ac.id/sju/jpe/article/view/39950

Belland, B. R., Kim, C., & Hannafin, M. J. (2013). A framework for designing scaffolds that improve motivation and cognition. *Educational Psychologist*, *48*(4), 243–270. https://doi.org/10.1080/00461520.2013.838920

Cerovac, M., & Keane, T. (2025). Early insights into Piaget's cognitive development model through the lens of the Technologies curriculum. *International Journal of Technology and Design Education*, *35*(1), 61–81. https://doi.org/10.1007/s10798-024-09906-5

Chu, S. K. W., Tse, S. K., & Chow, K. (2011). Using collaborative teaching and inquiry project-based learning to help primary school students develop information literacy and information skills. *Library & Information Science Research*, *33*(2), 132–143. https://doi.org/10.1016/j.lisr.2010.07.017

Cintang, N., Setyowati, D. L., & Handayani, S. S. D. (2018). The obstacles and strategy of project-based learning implementation in elementary school. *Journal of Education and Learning (EduLearn)*, *12*(1), 7–15. https://doi.org/10.11591/edulearn.v12i1.7045

Citraningtyas, C. E. C., Utami, I. P. T., & Rahmi, F. N. (2022, December). Technology and children's books: Digital talking books as a media for communicating 21st-century skills. In

International Conference on Intelligent Technologies (pp. 369–379). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-1912-3_33

Creswell, J. W., & Poth, C. N. (2016). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage Publications.

Dai, D. Y. (2015). A Jeffersonian vision of nurturing talent and creativity: Toward a more equitable and productive gifted education. *Asia Pacific Education Review*, *16*, 269–279. https://doi.org/10.1007/s12564-015-9364-y

Dai, D. Y. (2020). Rethinking human potential from a talent development perspective. *Journal for the Education of the Gifted*, *43*(1), 19–37. https://doi.org/10.1177/0162353219897850

de Jong, T. (2006). Scaffolds for scientific discovery learning. In J. Elen & R. E. Clark (Eds.), *Handling complexity in learning environments: Theory and research* (pp. 107–128). Elsevier.

Đerić, I., Malinić, D., & Đević, R. (2021). Project-based learning: Challenges and implementation support. *Problems and Perspectives of Contemporary Education*, 52–73. https://ipir.ipisr.org.rs/bitstream/handle/123456789/657

Dodgson, J. E. (2017). About research: Qualitative methodologies. *Journal of Human Lactation*, *33*(2), 355–358. https://doi.org/10.1177/0890334417698693

Ferreira, V. G., & Canedo, E. D. (2020). Design sprint in classroom: Exploring new active learning tools for project-based learning approach. *Journal of Ambient Intelligence and Humanized Computing*, *11*(3), 1191–1212. https://doi.org/10.1007/s12652-019-01285-3

Ferrero, M., Vadillo, M. A., & León, S. P. (2021). Is project-based learning effective among kindergarten and elementary students? A systematic review. *PLOS ONE*, *16*(4), e0249627. https://doi.org/10.1371/journal.pone.0249627

Fitriani, N., & Zaini, M. (2025). Analysis of the implementation of Merdeka curriculum in mathematics learning based on Jean Piaget's cognitive development theory in junior high school. *Rangkiang Mathematics Journal*, *4*(1), 42–51. https://doi.org/10.24036/rmj.v4i1.66

Flick, L. B. (2000). Cognitive scaffolding that fosters scientific inquiry in middle level science. *Journal of Science Teacher Education*, *11*(2), 109–129. https://doi.org/10.1023/A:1009464707968

Grönman, S., Lindfors, E., & Rönkkö, M. L. (2024). Design thinking in early childhood education and care: A literature review and consideration from the perspective of young learners' craft, design, and technology education. *International Journal of Technology and Design Education*, 1–21. https://doi.org/10.1007/s10798-024-09944-z

Harris, M. J. (2014). *The challenges of implementing project-based learning in middle schools* (Doctoral dissertation, University of Pittsburgh).

Humaira, T., & Ninawati, M. (2023). Development of contextual media diorama of water cycle in science subject in elementary school. *Jurnal Cakrawala Pendas*, *9*(4), 631–641. https://doi.org/10.31949/jcp.v9i4.5653

Hussein, B. (2021). Addressing collaboration challenges in project-based learning: The student's perspective. *Education Sciences*, *11*(8), 434. https://doi.org/10.3390/educsci11080434

Imaduddin, M., Sholikhati, S., & In'ami, M. (2021). STEM education research in Indonesian elementary schools: A systematic review of project-based learning. *Elementary: Islamic Teacher Journal*, *9*(2), 201–228. https://doi.org/10.21043/elementary.v9i2.11552

Jatisunda, M. G., & Nahdi, D. S. (2020). Kemampuan pemecahan masalah matematis melalui pembelajaran berbasis masalah dengan scaffolding. *Jurnal Elemen*, *6*(2), 228–243. https://doi.org/10.29408/jel.v6i2.2042

Jeon, K., Jarrett, O. S., & Ghim, H. D. (2014). Project-based learning in engineering education: Is it motivational? *International Journal of Engineering Education*, *30*(2), 438–448. https://www.researchgate.net/publication/285579124

Johari, A., & Bradshaw, A. C. (2008). Project-based learning in an internship program: A qualitative study of related roles and their motivational attributes. *Educational Technology Research and Development*, *56*, 329–359. https://doi.org/10.1007/s11423-006-9009-2

Kaldi, S., Filippatou, D., & Govaris, C. (2011). Project-based learning in primary schools: Effects on pupils' learning and attitudes. *Education 3–13*, *39*(1), 35–47. https://doi.org/10.1080/03004270903179538

Karahoca, D., Karahoca, A., & Uzunboylub, H. (2011). Robotics teaching in primary school education by project based learning for supporting science and technology courses. *Procedia Computer Science*, *3*, 1425–1431. https://doi.org/10.1016/j.procs.2011.01.025

Krajcik, J., Schneider, B., Miller, E. A., Chen, I. C., Bradford, L., Baker, Q., ... & Peek-Brown, D. (2023). Assessing the effect of project-based learning on science learning in elementary schools. *American Educational Research Journal*, *60*(1), 70–102. https://doi.org/10.3102/00028312221129247

Lam, S. F., Cheng, R. W. Y., & Ma, W. Y. (2009). Teacher and student intrinsic motivation in project-based learning. *Instructional Science*, *37*, 565–578. https://doi.org/10.1007/s11251-008-9070-9

Maslin, K., Murcia, K., Blackley, S., & Lowe, G. (2025). 'Sky's the limit': A case study in fostering young children's creativity during STEM online learning experiences. *The Australian Educational Researcher*, *52*(1), 743–764. https://doi.org/10.1007/s13384-024-00739-8

Meifang, W. (2025). Piaget's theory of moral development. In *The ECPH Encyclopedia of Psychology* (pp. 1105–1106). Springer Nature Singapore. https://doi.org/10.1007/978-981-97-7874-4_223

Meusburger, P. (2009). Milieus of creativity: The role of places, environments, and spatial contexts. In *Milieus of creativity: An interdisciplinary approach to spatiality of creativity* (Vol. 2, pp. 97–153). Springer. https://doi.org/10.1007/978-1-4020-9877-2

Meyer, D. K., Turner, J. C., & Spencer, C. A. (1997). Challenge in a mathematics classroom: Students' motivation and strategies in project-based learning. *The Elementary School Journal*, *97*(5), 501–521. https://doi.org/10.1086/461878

Mnguni, L. E. (2014). The theoretical cognitive process of visualization for science education. *SpringerPlus*, *3*, 1–9. https://doi.org/10.1186/2193-1801-3-184

Napitupulu, S. P., & Murniarti, E. (2024). Analisis keterlibatan siswa menengah pertama dalam pembelajaran berbasis proyek pada kurikulum merdeka. *Jurnal Kepemimpinan dan Pengurusan Sekolah*, *9*(2), 172–178. https://doi.org/10.34125/jkps.v9i2.450

Newton, L., & Newton, D. (2010). Creative thinking and teaching for creativity in elementary school science. *Gifted and Talented International*, *25*(2), 111–124. https://doi.org/10.1080/15332276.2010.11673575

Noor, S. A., Alqadri, M., & Ashari, W. (2024). Exploring the potential of project based education in a challenging and motivating approach for students. *Educia Journal*, *2*(1), 36–45. https://doi.org/10.71435/610406

O'Donnell, A. M., Dansereau, D. F., & Hall, R. H. (2002). Knowledge maps as scaffolds for cognitive processing. *Educational Psychology Review*, *14*, 71–86. https://doi.org/10.1023/A:1013132527007

Oh, J. E., Chan, Y. K., & Kim, K. V. (2020). Social media and e-portfolios: Impacting design students' motivation through project-based learning. *IAFOR Journal of Education*, *8*(3), 41–58. https://doi.org/10.22492/ije.8.3.03

Oogarah-Pratap, B., Bholoa, A., & Ramma, Y. (2025). Stage theory of cognitive development—Jean Piaget. In *Science education in theory and practice: An introductory guide to learning theory* (pp. 125–142). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-81351-1_8

Park, H., McCormick, M., & Park, J. H. (2025). Using a social-ecological framework to examine the cognitive development of elementary school children in the US. *BMC Psychology*, *13*(1), 209. https://doi.org/10.1186/s40359-025-02416-6

Paz-Baruch, N., Grovas, G., & Mevarech, Z. R. (2025). The effects of meta-creative pedagogy on elementary school students' creative thinking. *Metacognition and Learning*, *20*(1), 9. https://doi.org/10.1007/s11409-025-09412-6

Putra, M. J. A. (2022). Development of audio visual media using diorama food chain materials for class V elementary school. *Education Technology Journal*, *1*(1), 24–32. https://doi.org/10.56787/edutech.v1i1.7

Rapuc, S., Jary, S., Vanderwert, R. E., Odd, D., & Chakkarapani, E. (2025). Cognitive development at late infancy and school age in children cooled for neonatal encephalopathy. *Pediatric Research*, 1–8. https://doi.org/10.1038/s41390-025-04152-4

Rasyid, A., Rinto, R., & Susanti, M. (2023). Project-based learning through the STEM approach in elementary schools: How to improve problem-solving ability. *Journal of Education for Sustainable Innovation*, *1*(1), 1–8. https://doi.org/10.56916/jesi.v1i1.477

Retno, R. S., Purnomo, P., Hidayat, A., & Mashfufah, A. (2025). Conceptual framework design for STEM-integrated project-based learning (PjBL-STEM) for elementary schools. *Asian Education and Development Studies*, *14*(3), 579–604. https://doi.org/10.1108/AEDS-08-2024-0188

Rodd, J. (1999). Encouraging young children's critical and creative thinking skills: An approach in one English elementary school. *Childhood Education*, *75*(6), 350–354. https://doi.org/10.1080/00094056.1999.10522056

Rosenshine, B., & Meister, C. (1992). The use of scaffolds for teaching higher-level cognitive strategies. *Educational Leadership*, *49*(7), 26–33. https://www.formapex.com/telechargementpublic/rosenshine1992a.pdf

Rustaman, N. Y., Afianti, E., & Maryati, S. (2018, May). STEM based learning to facilitate middle school students' conceptual change, creativity and collaboration in organization of living system topic. In *Journal of Physics: Conference Series* (Vol. 1013, No. 1, p. 012021). IOP Publishing. https://doi.org/10.1088/1742-6596/1013/1/012021

Sitorus, J. (2016). Students' creative thinking process stages: Implementation of realistic mathematics education. *Thinking Skills and Creativity*, *22*, 111–120. https://doi.org/10.1016/j.tsc.2016.09.007

Smare, Z., & Elfatihi, M. (2023). A systematic review of research on creative thinking in primary education: Focus on empirical methodologies. *Issues in Educational Research*, *33*(2), 752–780. https://search.informit.org/doi/reader/10.3316/informit.303147088617097

Stoica, A. M. (2024). Project-based learning—a tool to increase students' intrinsic motivation. *Educatia 21*, (29). https://doi.org/10.24193/ed21.2024.29.07

Suler, J. R. (1980). Primary process thinking and creativity. *Psychological Bulletin*, *88*(1), 144. https://doi.org/10.1037/0033-2909.88.1.144

Tascı, B. G. (2015). Project based learning from elementary school to college, tool: Architecture. *Procedia - Social and Behavioral Sciences*, *186*, 770–775. https://doi.org/10.1016/j.sbspro.2015.04.130

Torrance, E. P. (1966). *Torrance tests of creative thinking*. Educational and Psychological Measurement. https://doi.org/10.1037/t05532-000

Tosolini, K. E., Damen, S., Janssen, M. J., & Minnaert, A. E. (2025, April). A Piagetian lens on cognitive development of children and youths with congenital deafblindness: A scoping review. In *Frontiers in Education* (Vol. 10, Article 1479668). Frontiers Media SA. https://doi.org/10.3389/feduc.2025.1479668

Treffinger, D. J. (1995). School improvement, talent development, and creativity. *Roeper Review*, *18*(2), 93–97. https://doi.org/10.1080/02783199509553707

Uttal, D. H., & Doherty, K. O. (2008). Comprehending and learning from 'visualizations': A developmental perspective. In *Visualization: Theory and practice in science education* (pp. 53–72). Springer Netherlands. https://doi.org/10.1007/978-1-4020-5267-5_3

Vogel, F., Wecker, C., Kollar, I., & Fischer, F. (2017). Socio-cognitive scaffolding with computer-supported collaboration scripts: A meta-analysis. *Educational Psychology Review*, *29*, 477–511. https://doi.org/10.1007/s10648-016-9361-7

Waldrip, B., & Prain, V. (2017). Engaging students in learning science through promoting creative reasoning. *International Journal of Science Education*, *39*(15), 2052–2072. https://doi.org/10.1080/09500693.2017.1362505

Wijaya, I. K. W. B., Suastra, I. W., & Muderawan, I. W. (2014). Pengaruh model pembelajaran generatif terhadap keterampilan berpikir kreatif dan keterampilan proses sains. *Jurnal Pendidikan dan Pembelajaran IPA Indonesia*, *4*(1). https://ejournal-pasca.undiksha.ac.id/index.php/jurnal_ipa/article/view/1296/998

Wintara, I. M. S., & Dasar, J. P. G. S. (2017). Pentingnya peran guru dalam pengembangan minat, bakat dan kreativitas siswa melalui ekstrakurikuler. *Pendidikan Guru Sekolah Dasar*, *3*(1), 1–12. https://www.researchgate.net/publication/315110215

Yang, K. K., Lee, L., Hong, Z. R., & Lin, H. S. (2016). Investigation of effective strategies for developing creative science thinking. *International Journal of Science Education*, *38*(13), 2133–2151. https://doi.org/10.1080/09500693.2016.1230685