EduBasic Journal: Jurnal Pendidikan Dasar
Vol. 7 No. 1, April 2025, pp. 76-86
https://ejournal.upi.edu/index.php/edubasic

Nature's Power: Integrating STEAM in Outdoor Learning to Unlocking Enhance 4C Skills and Science Pedagogical Knowledge

Jupriyanto[1]✉, Yunita Sari[2], Ratna Hidayah[3] & Moh Salimi[4]

[1]✉Universitas Islam Sultan Agung, jupriyanto@unissula.ac.id, Orcid ID: 0000-0002-7746-9240
[2] Universitas Islam Sultan Agung, yunitasari@unissula.ac.id, Orcid ID: 0000-0003-4991-7453
[3] Universitas Sebelas Maret, ratnahidayah@staff.uns.ac.id, Orcid ID: 0000-0001-9943-0390
[4] Universitas Sebelas Maret, salimi@staff.uns.ac.id, Orcid ID: 0000-0002-4901-7415

Article Info

History of Article
Received:
02 April 2025
Revised:
19 April 2025
Published:
30 April 2025

Abstract

Outdoor learning, as a form of science pedagogical knowledge, plays a vital role in equipping elementary learners with 21st-century competencies. This qualitative case study explores how outdoor learning at SD Alam Ungaran, a nature-based Islamic elementary school in Indonesia, can foster the development of critical thinking, creativity, communication, and collaboration (4C) skills grounded in a STEAM-integrated thematic curriculum. This study collected data through document analysis, semi-structured interviews, and direct classroom observations. Data was analyzed by emphasizing coding, condensation, and thematic interpretation via NVivo 12 Pro. Findings revealed that outdoor learning significantly enhances 4C skills through experiential and project-based activities embedded in real-world environmental contexts. Students' critical thinking skill is nurtured through inquiry and direct observation, while the creativity is stimulated through innovative ecological projects. Students developed their communication skills via interactive group discussions and presentations, and reinforced their collaboration skills through cooperative tasks such as market day and eco-projects. Moreover, students enriched their pedagogical science knowledge through the integration of STEAM concepts in authentic field activities. The SD Alam Ungaran integrated STEAM concepts and environmental ethics uniquely further to support the development of students' holistic moral, emotional, and social skills. The implications of these results can be a best practice for schools to create an integrative curriculum that supports the development of 21st-century skills.

Keywords: Nature School, Outdoor Learning, Science Pedagogical Knowledge, STEAM

How to cite: Jupriyanto, Sari, Y., Hidayah, R., & Salimi, M. (2025). Nature's power: Integrating STEAM in outdoor learning to unlocking enhance 4C skills and science pedagogical knowledge. *EduBasic Journal: Jurnal Pendidikan Dasar*, *7*(1), 76-86.

e-ISSN: 2549-4562, p-ISSN: 2987-937X

Info Artikel

Riwayat Artikel
Diterima:
02 April 2025
Direvisi:
19 April 2025
Diterbitkan:
30 April 2025

Abstrak

Pembelajaran di luar ruangan (*outdoor*), sebagai salah satu bentuk pengetahuan pedagogis sains, memainkan peran penting dalam membekali siswa sekolah dasar dengan kompetensi abad ke-21. Studi kasus kualitatif ini mengeksplorasi bagaimana pembelajaran luar kelas di SD Alam Ungaran, sebuah sekolah dasar Islam berbasis alam di Indonesia, dapat mendorong pengembangan keterampilan berpikir kritis, kreativitas, komunikasi, dan kolaborasi (4C) yang dilandasi oleh kurikulum tematik yang terintegrasi dengan STEAM. Penelitian ini mengumpulkan data melalui analisis dokumen, wawancara semi-terstruktur, dan observasi langsung di kelas. Data dianalisis dengan menekankan pada pengkodean, kondensasi, dan interpretasi tematik melalui NVivo 12 Pro. Temuan penelitian ini menunjukkan bahwa pembelajaran di luar ruangan secara signifikan meningkatkan keterampilan 4C melalui kegiatan berbasis pengalaman dan proyek yang tertanam dalam konteks lingkungan dunia nyata. Kemampuan berpikir kritis siswa dipupuk melalui penyelidikan dan pengamatan langsung, sementara kreativitas dirangsang melalui proyek ekologi yang inovatif. Siswa mengembangkan keterampilan komunikasi mereka melalui diskusi dan presentasi kelompok interaktif, dan memperkuat keterampilan kolaborasi mereka melalui tugas-tugas kooperatif seperti Market Day dan proyek lingkungan. Selain itu, para siswa memperkaya pengetahuan sains pedagogis mereka melalui integrasi konsep STEAM dalam kegiatan lapangan yang otentik. SD Alam Ungaran mengintegrasikan konsep STEAM dan etika lingkungan secara unik untuk mendukung pengembangan keterampilan moral, emosional, dan sosial siswa secara holistik. Implikasi dari hasil penelitian ini dapat menjadi praktik terbaik bagi sekolah untuk menciptakan kurikulum integratif yang mendukung pengembangan keterampilan abad ke-21.

Kata Kunci: Sekolah Alam, Pembelajaran Outdoor, Pengetahuan Pedagogis Sains, STEAM

Cara Mensitasi: Jupriyanto, Sari, Y., Hidayah, R., & Salimi, M. (2025). Nature's power: Integrating STEAM in outdoor learning to unlocking enhance 4C skills and science pedagogical knowledge. *EduBasic Journal: Jurnal Pendidikan Dasar*, *7*(1), 76-86.

e-ISSN: 2549-4562, p-ISSN: 2987-937X

INTRODUCTION

Innovative approaches, such as outdoor learning, are urgently needed in today's educational world to face future challenges. Conventional learning methods generally prioritize theoretical aspects and offer minimal practical application, limiting students' ability to apply classroom-acquired knowledge to real-world contexts. Meanwhile, the rapid advancement of information technology, while providing various conveniences, has contributed to a decline in students' social and emotional competencies. In this case, outdoor learning activities offer an alternative that enables students to interact with nature while nurturing interpersonal and intrapersonal skills aligned with 21st-century education goals.

In addition, environmental degradation and climate change are urgent concerns that threaten the sustainability of life on Earth. Outdoor learning is increasingly viewed as a transformative educational approach that connects learners to their environment through experiential, contextual, and inquiry-based methods. One growing movement supporting this is the Nature School model, which focuses on nature immersion, exploration, and environmentally responsible learning. Nature Schools integrate ecological education with broader academic goals, including STEAM (Science, Technology, Engineering, Arts, Mathematics), to promote well-rounded competencies in students.

Several countries have established successful Nature School models with flexible curricula that integrate outdoor learning. In Canada, the Forest School model combines nature-based learning with formal academic outcomes, fostering children's curiosity and creativity through outdoor experiences (Boileau & Dabaja, 2020). In Sweden, the Skogsmulle program introduces ecology and sustainability concepts through direct forest interactions, allowing children to engage in nature-based learning that fosters stewardship, agency, and ecological literacy (Marty et al., 2018). These schools demonstrate that outdoor learning is not merely recreational but a rigorous pedagogical process grounded in STEAM integration.

A growing body of international research confirms that outdoor learning can effectively develop learners' critical thinking, creativity, communication, and collaboration. It has been observed by Cincera et al. (2021) and Parno et al. (2020) that outdoor experiential learning fosters critical thinking through problem-solving activities. Similarly, Abimanyu et al. (2024) have reported increased learner engagement and creativity through activities like replanting forests and upcycling materials. Some studies also demonstrated that natural settings improve student motivation and enhance collaborative learning outcomes (Shaner et al., 2016; Kazeni & Maleka, 2020; Molina et al., 2021).

Through collaboration and experiential projects, outdoor activities also hone students' values-based competencies such as cooperation, responsibility, and leadership. Nature Schools, while focused on academic growth, equally prioritize character development, a balance increasingly endorsed in STEAM learning models. In programs like that of a study by Boileau and Dabaja (2020) in Canada, Forest School learners experience improved socio-emotional and communication skills due to child-led, inquiry-driven practices. Specifically, developing learners' skills, especially from the elementary level, is essential in preparing individuals to face rapid changes and global competition. As stated by Widodo & Wardani (2020), 4C skills are foundational for lifelong learning and adaptability. Integrating these skills within outdoor, STEAM-oriented settings provides not only cognitive development but also cultivates empathy, cooperation, and respect for diversity, skills critical to 21st-century global citizenship.

Furthermore, Valladares (2021) emphasized that 21st-century education should equip learners with skills beyond academic knowledge. The 4C skills, i.e., critical thinking, communication, collaboration, and creativity, are central to this framework. These competencies are best fostered through problem-based, project-based, and inquiry-based learning methods that align closely with outdoor learning. Integrating STEAM within outdoor education provides practical, hands-on opportunities for learners to explore, design, test, and evaluate, promoting more profound understanding and cross-disciplinary thinking.

Agricultural activities, environmental explorations, and outdoor projects integrated with academic subjects allow students to engage in real-life applications of classroom concepts. Several studies argue that such integrated outdoor approaches improve both cognitive achievement and personal growth. Nature-based learning fosters not only ecological sensitivity but also systems thinking, a key component of STEAM education and scientific literacy (Bauer & Booth, 2019; Cotič et al., 2020; Waters, 2024).

In Indonesia, models of Nature Schools are emerging, though they are underrepresented in scholarly literature. One example is SD Alam Ungaran, located in the Semarang region at the foot of Mount Ungaran. With kindergarten to junior high levels, this school adopts a nature-based education approach grounded in the Qur'an and Hadith, emphasizing exploration, environmental care, and spiritual values. The physical environment is intentionally designed with open, unpartitioned classrooms to maximize sensory and ecological experiences.

Initial observations suggest that SD Alam Ungaran was founded in 2007 by three parents concerned about their children's discomfort with traditional schooling. Their vision was to create an educational space where children learn joyfully without being burdened by rigid academics. This origin story reflects a pedagogical response rooted in child-centeredness, well-being, and freedom to explore. Islamic ethics, local wisdom, and nature awareness deeply influence the learning environment.

Unlike typical formal schools, SD Alam Ungaran allows students to learn beyond the walls of the classroom, emphasizing unstructured outdoor exploration. This practice enables students to encounter real-world problems and phenomena directly, supporting inquiry-based science learning and values formation. The curriculum is not compartmentalized but interwoven across themes, integrating STEAM content through contextual, outdoor applications, an approach aligned with nature-based learning principles, and pedagogical content knowledge.

Critical thinking at SD Alam Ungaran is fostered through nature investigations and project activities, encouraging students to evaluate evidence, test hypotheses, and interpret findings. It is asserted in studies of Cahyaningtyas et al. (2020) and Jupriyanto & Sari (2019) that critical thinking in this context includes structured decision-making, problem-solving, and metacognitive reflection. Outdoor settings provide authentic problems that require analytical engagement, mirroring real-life decision-making environments.

Creativity emerges when students are challenged to propose solutions to ecological or social problems they encounter during outdoor learning. As ('Adiilah & Haryanti, 2023) elucidated, creativity involves producing original ideas and adaptive solutions. Projects such as eco-art, water filtration prototypes, and garden planning stimulate students' imagination while anchoring them in real-world contexts, fulfilling the STEAM component of design-based thinking.

Collaboration is evident as students engage in group-based tasks such as community mapping, river clean-ups, or garden maintenance. As Munazad et al. (2023) explained, collaboration is built through shared responsibilities and mutual accountability. At SD Alam Ungaran, students negotiate roles, resolve conflicts, and coordinate efforts, building teamwork, leadership, and social cohesion.

Communication is cultivated through peer presentations, documentation of outdoor projects, and reflective discussions. Nisa and Sujarwo (2021) stated that communication in learning entails expressing ideas clearly, responding to feedback, and interpreting symbols. These skills are embedded in the school's pedagogy, where learners are encouraged to share insights from their observations and collaboratively discuss findings, strengthening their verbal, nonverbal, and visual communication literacies.

Outdoor learning, as implemented at SD Alam Ungaran, encourages students to observe, experiment, and draw conclusions from their environment. It has been highlighted by many researchers such as Antari et al. (2021) and Kiviranta et al. (2024), that outdoor settings provide authentic learning opportunities where children apply science process skills and integrate multisensory input. The emphasis on field-

based experience enhances scientific reasoning and strengthens science pedagogical knowledge.

Learning becomes more engaging and meaningful when it connects directly with students' surroundings. When facilitated effectively, outdoor learning boosts students' motivation, autonomy, and participation. As Hartik et al. (2023) and Setiawati et al. (2023) observed, learning in nature increases student interest and fosters a sense of ownership over learning processes, particularly when students can explore problems relevant to their communities.

Therefore, this study aims to explore how outdoor learning at SD Alam Ungaran contributes to the development of 4C skills and strengthens science pedagogical knowledge through STEAM-integrated, nature-based education. While numerous studies confirm the benefits of outdoor learning in general, research exploring STEAM-based, outdoor learning models within Islamic Nature Schools in Indonesia seeks to fill that gap by examining how pedagogical innovation in a uniquely contextualized setting can support 21st-century skills and offer alternative models for integrated humanistic science education.

METHODS

This study employed a qualitative approach with a case study method to explore how outdoor learning contributes to the development of 4C skills (critical thinking, creativity, communication, and collaboration) and science pedagogical knowledge in a Nature School setting. A qualitative case study enables the researchers to investigate real-life educational phenomena deeply and contextually.

The research was conducted at SD Alam Ungaran, a nature-based school located in Central Java, Indonesia. The main research questions were: (1) How is outdoor learning implemented to foster 4C skills? Moreover, (2) How does outdoor learning contribute to the development of science pedagogical knowledge through STEAM integration?

The data were collected through observations, semi-structured interviews, and document analysis. Observations focused on outdoor science-related activities; interviews were conducted with two teachers, the principal, and eight students (grades 4–6) were recruited through purposive sampling; relevant documents such as lesson plans, project reports, and student reflections were analyzed. The researchers also served as the primary instrument, engaging directly with the setting to interpret phenomena contextually. The research indicators were derived from the 21st Century Learning Framework and STEAM integration models, including collaboration (teamwork and shared responsibility), critical thinking (problem-solving and evidence-based analysis), creativity (idea generation and innovation), communication (expression and interaction), and science pedagogical knowledge (application of science in natural settings).

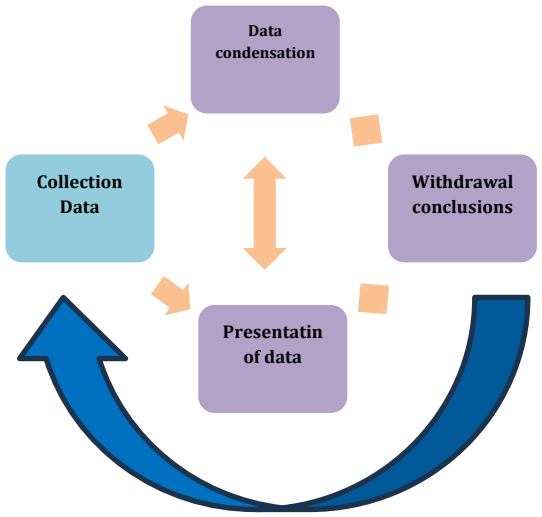

Figure 1. Data Analysis Technique

To ensure validity and trustworthiness, the study used triangulation across methods and sources, member checking to confirm interpretation accuracy, and audit trails for transparency. Prolonged engagement in the field supported the credibility of the findings. Instruments such as observation guides, interview protocols, and document analysis rubrics were aligned with the study's indicators to maintain consistency.

Data were analyzed using the interactive model of Miles & Huberman (Ridder, 2014), involving four stages: data collection, data condensation (coding using NVivo 12 Pro), data display (theme matrices), and drawing/verifying conclusions. The analysis

used both first-cycle coding (descriptive and in vivo) and second-cycle coding (pattern coding) to reveal relationships between outdoor learning practices and the development of 4C skills and science pedagogical knowledge. These findings were then interpreted to explain how a contextualized STEAM-based Nature School approach fosters holistic skill development in elementary learners.

RESULTS AND DISCUSSION

Results

Implementation of Outdoor Learning to Foster 4C Skills

The Kurikulum Merdeka adopted by SD Alam Ungaran is specifically designed to integrate academic learning with experiential activities in natural environments, forming a rich foundation for developing 4C skills. This integrated curriculum fosters collaboration among learners, teachers, and the surrounding community while enabling students to apply abstract concepts in authentic, real-world contexts, aligning closely with the tenets of STEAM education. The learning strategy reflects 21st-century education principles, in which learning is active, inquiry-based, and student-centred (Carter et al., 2024).

Holistic assessment in the school includes cognitive, affective, and psychomotor domains, ensuring comprehensive learner development. The school's vision and mission combine nature-based and Islamic values, aiming to nurture independent, scientific, and character-driven learners. The Spider Web model used in the lesson plan serves as an effective medium for interdisciplinary learning, connecting multiple subjects through central, real-life themes, thus forming an ideal framework to develop creativity and critical thinking.

Evaluations from thematic learning and extracurricular activities revealed that students not only gain theoretical knowledge but also develop practical skills relevant to 4C competencies. As students design, present, and reflect on their projects, these activities inherently reinforce communication and creativity.

Based on the NVivo 12 project maps in Figure 2, the development of 4c skills in natural schools can be implemented through outdoor learning. Sekolah Dasar Alam Ungaran believes every child is unique and has potential that can be developed according to their interests. Therefore, SD Alam Ungaran always facilitates what students want with various activities to develop critical thinking, collaboration, creativity, and communication skills.

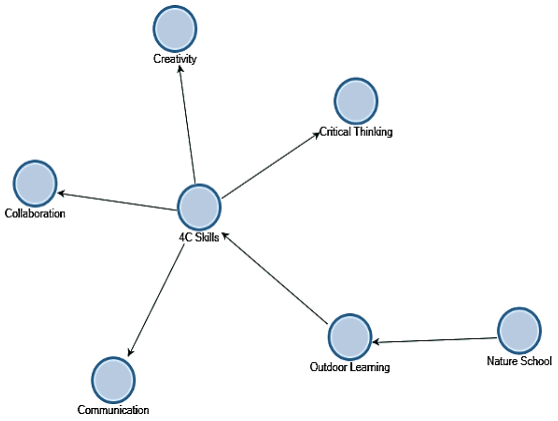

Figure 1. 4C Skills Maps and Outdoor Learning

SD Alam Ungaran also emphasizes understanding and support for outdoor learning by implementing a thematic curriculum integrating environmental exploration as the central teaching-learning process. The philosophy of establishing SD Alam Ungaran is based on creating a fun learning experience without excessive academic pressure and is oriented toward developing students' full potential.

Outdoor Learning Activities Design

Outdoor learning at SD Alam Ungaran is designed to foster critical thinking skills through nature exploration and inquiry-based learning. Activities such as observing plant cycles in rice fields or studying environmental changes in the forest stimulate learners' analytical ability. For example, when learning about the concept of changes in states of matter, students are engaged in contextual experiments that require direct observation and hypothesis formulation. These practices align with Kolb's Experiential Learning Theory (Romero-Ariza, 2017), especially the stages of concrete experience and reflective observation. Similar results were found by Zheng and Lee (2018), where natural

immersion significantly enhanced students' scientific reasoning and observation skills.

The school also emphasizes communication and collaboration through structured activities like the Market Day or Eco-Challenge Projects. These group events require students to plan, distribute tasks, and interact with peers and the surrounding community. During these activities, learners communicate ideas, negotiate roles, and present their products or services, strengthening both verbal and non-verbal communication. These findings resonate with the research of Fuertes et al. (2020) and Turekulova et al. (2024), who documented improved interpersonal skills and oral communication in students participating in community-based learning.

Moreover, creativity is nurtured by integrating hands-on projects into thematic learning modules. Activities such as designing solar ovens or creating posters to raise awareness about biodiversity allow students to express novel ideas while applying scientific knowledge. The flexibility of the curriculum supports divergent thinking and innovation, as learners are encouraged to explore and prototype sustainable solutions. It has been highlighted by Aguilera and Ortiz-Revilla (2021) that science learning becomes more meaningful when it invites learners to invent, redesign, and solve real problems, precisely the experience promoted at SD Alam Ungaran.

Through group projects, such as waste management and market day events, students demonstrate the ability to collaborate effectively, share responsibilities, and practice consensus. Outdoor collaborative tasks build leadership and group resilience. Activities in nature allow learners to take on diverse roles and reflect on their group dynamics, strengthening their collaboration skills. These experiences are rarely found in rigid classroom environments, highlighting the transformative power of nature-based learning.

The implementation of outdoor learning in encouraging 4C skills at SD Alam Ungaran can be described as shown in Figure 3.

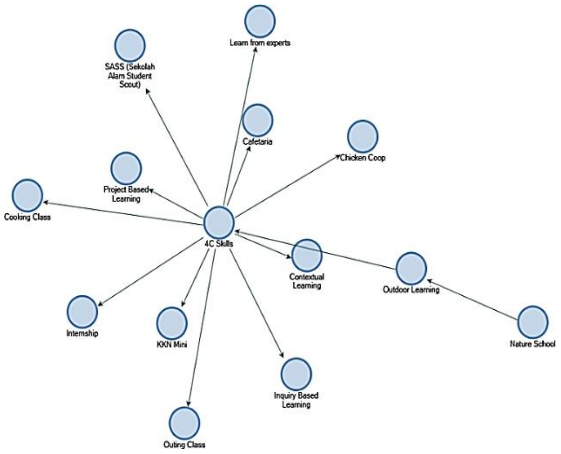

Figure 2. Implementation of Outdoor Learning to 4C Skills SD Alam Ungaran

The learning process at SD Alam Ungaran reflects all four stages of Kolb's experiential model: concrete experiences through direct activities (e.g., farming), reflective observations (e.g., peer discussions), abstract conceptualizations (e.g., linking field experiences to science concepts), and active experimentation (e.g., designing solar ovens). These practices enrich science pedagogical knowledge, helping students internalize scientific processes through multidisciplinary tasks. This is supported by Cotič et al. (2020) and Martín-Páez et al. (2019), asserting that real-world integration reinforces both content knowledge and process skills in science.

Discussion

Development of STEAM through the 4C Skills and Science Pedagogical Knowledge

Teachers at SD Alam Ungaran apply a flexible and participatory approach that encourages students to be co-creators of their learning journey. By involving learners in deciding outdoor activities and outing locations, teachers foster student agency and stimulate critical thinking and creativity. This practice reflects principles of student-centred and inquiry-based education embedded in the 21st-century skills framework (O'Toole et al., 2020) and the Experiential Learning Cycle (Cotič et al., 2020). This is also in line with the research of Mann et al. (2022) and Waters (2024), which emphasizes the importance of learner autonomy in promoting cognitive and affective engagement.

The integration of nature-based education into the curriculum becomes a strategic platform for holistic student development. This aligns with the findings of Aguilera and Ortiz-Revilla (2021), emphasizing the importance of linking science content with emotionally and socially engaging experiences. The use of outbound games and thematic projects facilitates collaboration among students. Group-based exploration tasks, such as mapping ecosystems or designing mini-gardens, promote leadership and interpersonal coordination, demonstrating the school's strong emphasis on collaboration as a core competence. These findings are consistent with research by Dean (2021) and Waters, 2024), which supports that learning in outdoor settings enhances group problem-solving and cooperative behaviour.

The science pedagogical knowledge of students is enhanced through authentic STEAM experiences such as studying biogas systems, water cycles, and organic fertilizer production. These activities enable learners to connect textbook science with real-world phenomena. By engaging directly with local contexts like beekeeping farms or traditional markets, students apply scientific inquiry in situ, constructing knowledge through tangible, interdisciplinary projects. Outdoor learning significantly improves learners' conceptual understanding when science content is situated in local, familiar contexts.

Learners' participation in reflective discussions and problem-based exploration leads to noticeable improvements in their ability to pose questions and reason critically. Questions about phenomena like soil colour changes after rainfall are evidence of deepened conceptual understanding. In group contexts, students enhance communication skills by expressing and defending their ideas. Learners in nature-rich environments develop higher-order questioning and scientific argumentation through repeated environmental engagement.

Practical experiences such as planting rice, managing school gardens, and reusing waste also stimulate learners' creativity. Students learn to innovate through real-world problems, such as turning waste into valuable products, thereby linking science learning with environmental ethics. This approach aligns with STEAM-based outdoor learning that activates both cognitive and affective domains by connecting imagination with scientific practice. The embeddedness of ecological and moral values in activities also resonates with the goals of education for sustainable development.

The novelty of this study lies in its focus on STEAM-integrated outdoor learning in an Islamic-based Nature School in Indonesia, a context that is underexplored in global literature. SD Alam Ungaran blends spiritual, ecological, and academic domains, providing a culturally rooted model of holistic learning.

One limitation of this study is its singular focus on one school context, which may not fully capture variability in nature-based learning implementations across regions. Additionally, while this study focuses on learner outcomes, it does not yet address how teacher training programs directly influence the quality of outdoor learning. Future research should expand to include comparative case studies across diverse cultural settings, as well as longitudinal studies tracking the long-term effects of outdoor learning on student competencies and character.

CONCLUSION

The findings of this research demonstrate that outdoor learning at SD Alam Ungaran effectively fosters the development of 4C skills through a contextual and experiential curriculum integrated with nature-based education. Students' direct engagement with the natural environment enhances their inquiry, reflection, and problem-solving abilities while encouraging creative expression, collaborative teamwork, and meaningful dialogue.

In addition to academic skill development, outdoor learning contributes significantly to learners' science pedagogical knowledge by providing real-world contexts to apply interdisciplinary STEAM concepts. The integration of thematic projects such as ecosystem mapping, solar energy utilization, and waste management enables students to build scientific understanding through hands-on, community-based experiences that support sustainability and environmental literacy.

ACKNOWLEDGEMENT

The authors thank the Lembaga Penelitian dan Pengabdian Masyarakat (LPPM) of Universitas Islam Sultan Agung for the financial support that made this research possible. The authors also thank SD Alam Ungaran for their cooperation and active contribution throughout the research.

REFERENCES

'Adiilah, I. I., & Haryanti, Y. D. (2023). Pengaruh model problem based learning terhadap kemampuan berpikir kreatif siswa pada pembelajaran IPA. *Papanda Journal of Mathematics and Science Research*, *2*(1), 49–56.

Abimanyu, I., Narulita, H., & Purwani, L. L. D. (2024). Kajian outdoor learning proses dalam pembelajaran siswa sekolah dasar: Studi pustaka. *JEMARI: Jurnal Edukasi Madrasah Ibtidaiyah*, *6*(1), 25–33.

Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity : A systematic literature review. *Education Sciences*, *11*(7), 331.

Antari, C. J., Triyogo, A., & Egok, A. S. (2021). Penerapan model outdoor learning pada pembelajaran tematik siswa di sekolah dasar. *Jurnal Basicedu*, *5*(4), 2209–2219.

Bauer, J.-R., & Booth, A. E. (2019). Exploring potential cognitive foundations of scientific literacy in preschoolers: Causal reasoning and executive function. *Early Childhood Research Quarterly*, *46*, 275–284.

Boileau, E. Y. S., & Dabaja, Z. F. (2020). Forest School practice in Canada : A survey study. *Journal of Outdoor and Environmental Education*, *23*, 225–240.

Cahyaningtyas, A. P., Sari, Y., & Pradana, A. B. A. (2020). High order thinking skills: How is it integrated with cognitive assessment? *Jurnal Ilmiah Pendidikan Dasar*, *7*(2), 109–120.

Carter, I., Harrington, C., & Ahrendt, S. (2024). An examination of an inquiry-based hybrid online/in-person science methods course. *International Journal of Science Education*, *47*, 1–19.

Cincera, J., Gallayova, Z., Kuciakova, S., & Goldman, D. (2021). Roots and shoots: Building bridges between schools and their communities. *Sustainability*, *13*(22), 12543.

Cotič, N., Plazar, J., Starčič, A. I., & Zuljan, D. (2020). The effect of outdoor lessons in natural sciences on students' knowledge, through tablets and experiential learning. *Journal of Baltic Science Education*, *19*(5), 747–763.

Dean, S. N. (2021). National park interpretation and place-based education: An integrative literature review. *Journal of Experiential Education*, *44*(4), 363–377.

Fuertes, M. T., Balaguer, C., Fernández, M. Y., & Fernández-Morilla. M. (2020). Improving communicative competence through social interaction: A service-learning methodology. *The Educational Review, USA*, *4*(11), 199–210.

Hartik, H., Novitasari, N., & Rahman, T. A. (2023). Penerapan metode outdoor learning untuk meningkatkan motivasi belajar di RA. *Al Hikmah: Indonesian Journal of Early Childhood Islamic Education*, *7*(1), 18–29.

Jupriyanto, J., & Sari, Y. (2019). The students' critical thinking skills on science learning subject at 5th grade in inquiry learning. *JPSD (Jurnal Pendidikan Sekolah Dasar)*, *5*(1), 127–136.

Kazeni, M., & Maleka, M. (2020). Strategies used by grade four educators to decode science terminology: A case study. *Perspectives in Education*, *38*(1), 197–210.

Kiviranta, L., Lindfors, E., Rönkkö, M., & Luukka, E. (2024). Outdoor learning in early childhood education : Exploring benefits and challenges. *Educational Research*, *66*(1), 102–119.

Mann, J., Gray, T., Truong, S., Brymer, E., Passy, R., Ho, S., Sahlberg, P., Ward, K., Bentsen, P., Curry, C., Cowper, R., & Mann, J. (2022). Getting out of the classroom and into nature : A systematic review of nature-specific outdoor learning on school children's learning and development. *Frontiers in Public Health*, *10*, 877058.

Martín-Páez, T., Carrillo-Rosúa, J., Lupiáñez-Gómez, J. L., & Vílchez-González, J. M. (2019). Analysis of the external assessment of the scientific-technological competence in 6th grade of Primary Education (2016). *Ensenanza de Las Ciencias*, *37*(2), 127–149.

Marty, L., Venturini, P., & Almqvist, J. (2018). Teaching traditions in science education in Switzerland, Sweden and France: A comparative analysis of three curricula. *European Educational Research Journal*, *17*(1), 51–70.

Molina, J., Hai, N. V, Cheng, P.-H., & Chang, C.-Y. (2021). SDG's quality education approach: Comparative analysis of natural sciences curriculum guidelines between Taiwan and Colombia. *Sustainability*, *13*(6), 3352.

Munazad, L., Hafizah, E., & Sauqina. (2023). Pengembangan modul pembelajaran IPA berbasis ICARE untuk memfasilitasi keterampilan kolaborasi siswa SMP/MTs. *Journal on Teacher Education*, *5*(1), 19–28.

Nisa, K., & Sujarwo. (2021). Efektivitas komunikasi guru terhadap motivasi belajar anak usia dini. *Jurnal Obsesi: Jurnal Pendidikan Anak Usia Dini*, *5*(1), 229–240.

O'Toole, J. M., McKoy, K., Freestone, M., & Osborn, J.-A. (2020). 'Scientific literacy': An exercise in model building. *Education Sciences*, *10*(8), 204.

Parno, Yuliati, L., Hermanto, F. M., & Ali, M. (2020). A case study on comparison of high school students' scientific literacy competencies domain in physics with different methods: PBL-STEM education, PBL, and conventional learning. *Jurnal Pendidikan IPA Indonesia*, *9*(2), 159–168.

Ridder, H.-G. (2014). Book review: Qualitative Data Analysis. A Methods Sourcebook. *German Journal of Human Resource Management*, *28*(4), 485–487.

Romero-Ariza, M. (2017). Inquiry-based learning: Is there enough evidence of its benefits in science education? *Revista Eureka*, *14*(2), 286–299.

Setiawati, E., Wijayanti, P. S., Rianto, & Sukasih. (2023). Efektivitas pembelajaran outdoor learning process terhadap peningkatan kerja sama, motivasi belajar, dan hasil belajar IPS siswa sekolah dasar. *Jurnal Paedagogy*, *10*(1), 115–125.

Shaner, S. E., Hooker, P. D., Nickel, A.-M., Leichtfuss, A. R., Adams, C. S., De La Cerda, D., She, Y., Gerken, J. B., Pokhrel, R., Ambrose, N. J., Khaliqi, D., Stahl, S. S., & Schuttlefield Christus, J. D. (2016). Discovering inexpensive, effective catalysts for solar energy conversion: An authentic research laboratory experience. *Journal of Chemical Education*, *93*(4), 650–657.

Turekulova, A., Mukhambetova, L., Chimgentbayeva, G., & Doshan, A. (2024). Social, labor, and economic behavior of young people in the context of the emergence of a digital society. *E3S Web of Conferences*, *537*, 02026.

Valladares, L. (2021). Scientific literacy and social transformation: Critical perspectives about science participation and emancipation. *Science and Education*, *30*(3), 557–587.

Waters, C. A. (2024). Exclusionary narratives in environmental studies: Lessons from an urban nature center. *Journal of Environmental Studies and Sciences*, *14*(3), 568–580.

Widodo, S., & Wardani, R. K. (2020). Mengajarkan keterampilan abad 21 4C (Communication, Collaboration, Critical Thinking and Problem Solving, Creativity and Innovation) di sekolah dasar. *MODELING: Jurnal Program Studi PGMI, 7*(2), 185–197.

Zheng, K.-H., & Lee, S.-T. (2018). When science literacy and reading literacy meet: Experimental study of science news reading strategy for high school students. *Journal of Research in Education Sciences*, *63*(4), 157–192.