International Journal of Biology Education Towards Sustainable Development
Vol.4, No.2, 2024, pp. 101-118
e-ISSN 2809-5073. DOI. 10.52889/ijbetsd.v4i2.554

Needs Analysis: Implementation of Outdoor STEM Learning in Biology Education at High School

Submitted 24 December 2024 Revised 31 December 2024 Accepted 31 December 2024

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Abstract

This study examined the preparation and implementation of outdoor learning by integrating STEM concepts into Biology Education. It highlights the opportunity for further investigation into how the STEM approach can enrich students' learning experiences in outdoor learning. The research uses a case study method with a qualitative approach, where data is collected through observations and interviews to understand the implementation of Outdoor STEM Learning in Biology Education at high schools. Data collection was conducted at two schools, with two Biology teachers as informants from one high school in Banten and Jakarta. The findings reveal that both schools have not yet implemented the Outdoor STEM Learning concept in Biology Education. However, both show a growing interest and curiosity to adopt it, especially with the implementation of the Merdeka Curriculum. Challenges such as limited resources, facilities, and teacher training pose obstacles, but it is hoped that this implementation could enhance learning experiences, strengthen the understanding of Biology, and develop students' character.

Keywords: Outdoor Learning, STEM, Biology, Skills, Environment

INTRODUCTION

Outdoor STEM learning represents an innovative approach that combines the principles of Science, Technology, Engineering, and Mathematics in natural settings to improve student engagement and understanding (Crompton, 2020; Triplett, 2023). Integrating outdoor learning into biology education allows learners to directly observe and interact with ecosystems, fostering inquiry-based exploration and problem-solving (Demir & Kose, 2022). Research highlights the growing importance of 21st-century skills, such as collaboration, critical thinking, and creativity, which can be nurtured through experiential learning opportunities (Mardhiyah et al., 2021; Triplett, 2023). This paper investigates the effectiveness of Outdoor STEM Learning in enhancing biology education and outlines practical strategies to address challenges associated with implementation.

The 21st century skills in education play an important role in shaping the nation's generation of quality because the learning process not only focuses on cognitive development but also emphasizes the importance of social and emotional skills development (Lubis *et al.,*

2023). The focus of the 21st century is the emergence of the knowledge-driven Revolution 4.0. However, knowledge alone is not enough to realize the Industrial Revolution 4.0. The foundation of quality human resources in today's development requires a balance between knowledge and skills (Mardhiyah *et al.,* 2021). Learning with the STEM (Science, Technology, Engineering, and Mathematics) approach has become a main pillar in efforts to prepare the younger generation to face a future increasingly dominated by technology. Along with the rapid development of technology, a deep understanding of science and technology, as well as related skills, is key to successfully participating in a society that is increasingly technology-oriented. Through the STEM approach, the learning process is not only about understanding scientific and mathematical concepts but also encourages students to hone their critical thinking, problem-solving, and creativity skills (Viviyanti, 2023). This is in line with 21st-century skills that focus on the 4Cs, namely critical thinking, communication, collaboration, and creativity. The achievement of 21st-century skills can be accomplished through the improvement of learning quality and the active role of education in helping to develop the potential of its students (Mardhiyah *et al.,* 2021).

In reality, now in Indonesia, and in other climes, the involvement of students in STEM activities is relatively in its nascent stage, with many showing less interested in STEM disciplines and careers (Suriyabutr & Williams, 2021). Amongst other strategies in our quest to mitigate this challenge, could be the intentional conduct of Outdoor Learning. Contextual learning outdoors is one of the ways of teaching that can bridge the gap between STEM concepts that are quite difficult and their applications in daily life so that they can make learning more meaningful (Crompton, 2020; Jituafua, 2020; Demir & Kose, 2022). Outdoor STEM activities provide opportunities to interact with complex issues, where the environment serves as a learning resource that supports the STEM learning process (Pitipornpapin *et al.,* 2024). Students' participation in Outdoor STEM Learning can increase their interest, activity, happiness, and understanding of STEM, and support future career aspirations (Son *et al.,* 2017). Outdoor Learning not only changes learning activities outside the classroom but also involves students interacting directly with nature and doing various activities that can aim to change students' attitudes towards the environment (Maulana & Saputra, 2018).

Previous research on Outdoor Learning such as Sari *et al.* (2023) based on the result of their literature study said that the application of Outdoor Learning is one of the alternatives (supports) to conduct biology learning that can develop students' scientific abilities and skills based on the experience gained while learning in the outdoors and can increase students' motivation to learn compared to students who study indoors. Then another study conducted

by Ariesandy (2021) stated that outdoor learning in the form of exploring the environment associated with learning motivation, can improve student learning outcomes in the topic of biology. This study compares students' learning outcomes by using Outdoor Learning methods in the form of exploring the environment (experimental class) and using conventional methods (control class). Then the research conducted by Noviani *et al.* (2023) where the study analyzed the improvement of students' Science Process skills through the application of STEM which had a positive impact on their learning outcomes in biology learning.

Other studies haves shown that outdoor learning has been applied to biology learning, but there are still few studies that combine the concept of "Outdoor STEM Learning" that integrates Science, Technology, Engineering, and Mathematics in outdoor learning. These previous studies focused more on cognitive learning outcomes, while the concept of Outdoor STEM Learning can also measure the impact of outdoor learning on affective assessment, which can increase students' learning motivation in biology learning. This research proposes to analyze how to prepare and apply outdoor learning by integrating STEM concepts into biology learning. This shows an opportunity to further research how STEM approaches can strengthen students' learning experience in Outdoor Learning.

METHOD

This research used a case study design with a qualitative approach. This design was chosen to explore in depth the implementation of Outdoor STEM Learning in Biology education at high schools. Case studies allow the researcher to understand phenomena in depth within real contexts. The population in this research includes biology teachers who are high school teachers with the selected sample being one of the high school schools located in Banten and Jakarta respectively. The instrument used in this research was an interview sheet. This sheet contains a list of questions designed to elicit information from Biology teachers regarding understanding, benefits, challenges, and needs in implementing Outdoor STEM Learning. The interview sheet was prepared based on the research objectives to ensure clarity and relevance of the questions asked.

This research was carried out through several stages. The first stage is preparation, where the researcher prepares research instruments in the form of interview sheets, and obtains permission from the school to carry out the research. Next, at the data collection stage, the researcher made observations in the school environment. Interviews were conducted with two Biology teachers from one of the high schools in Banten and Jakarta to gain in-depth information regarding understanding, benefits, challenges, and needs in implementing

Outdoor STEM Learning. Data obtained from interviews were then transcribed and analyzed qualitatively using thematic analysis techniques to identify main patterns and themes. The final stage is preparing a report in the form of a scientific article, where the results of data analysis are compiled and integrated into a research report to present the main findings and discussion following the research objectives. Data obtained from interviews were analyzed qualitatively using thematic analysis. The process begins with transcribing the interview data, then the data is read repeatedly to understand the overall content so that it can help organize research systematically. This analysis aims to explore patterns and relationships that explain teachers' understanding, benefits, challenges and needs in implementing Outdoor STEM Learning in Biology learning in high school.

RESULTS AND DISCUSSION

The Tabel 1 dan Table 2 show the results of interviews that have been conducted with one of the high school biology teachers in Banten and Jakarta, Indonesia.

Tabel 1. Results of Interviews with High School Biology Teachers in Banten

No.	Aspect and Questions	Answer
	Experience and Skills of Teacher	
1.	How has your experience been teaching biology in the classroom?	The source has been teaching at the high school since 2018, and the classes he is responsible for are 10th and 12th grade.
2.	So far in learning biology, what learning models are often used?	During his teaching experience, the resource person more often uses commonly used learning models such as PBL, PJBL, Inquiry Learning, Jigsaw, and gallery walk, but it is not uncommon for the resource person to carry out a practicum in Biology learning.
3.	How do the students respond to that learning?	Students always respond enthusiastically to the new learning model because it doesn't seem monotonous.
4.	Have you previously known or heard of the STEM-based Outdoor Learning teaching model?	One of the teachers at that school once implemented Outdoor Learning but did not integrate STEM.
5.	What is your opinion on the importance of outdoor learning for biology subjects?	Of course, it is a good thing because it can enhance students' understanding.
6.	Do you feel you have sufficient skills to implement Outdoor STEM Learning?	The abilities or skills of the teacher need to be honed because the teacher will guide the students in their learning process.
7.	What type of training do you need to help you implement Outdoor STEM Learning?	The necessary training can take the form of workshops that provide hands-on practice.

No.	Aspect and Questions	Answer
	Student Involvement	
8.	To what extent do you see students engaged in biology learning currently?	Based on the informant's experience, students are generally enthusiastic and active in biology learning because the teacher uses engaging teaching media such as props and videos.
9.	What do you think can improve learner engagement in biology lessons?	Learners must be involved in the learning process, so it is not uncommon for sources to carry out practicum so that students are more active in the learning process.
	Curriculum and Learning Materials	
10.	Do you think the current biology curriculum allows for the implementation of Outdoor learning?	The current curriculum, which is the Merdeka Curriculum, can support the Outdoor STEM Learning process, especially in terms of flexible and varied learning styles.
11.	What topics in biology do you think can be taught better through outdoor activities?	Various materials can be taught in Outdoor STEM Learning, such as material on growth and development, biodiversity, plants, and environmental pollution.
	Resources and Facilities	
12.	Does your school have sufficient resources or facilities to support outdoor learning?	Resources are quite supportive due to the school's location close to open nature. Issues that occur in the environment around the school include the need for clean water and waste utilization/processing which may be related to Biology learning material.
13.	What resources and facilities do you think are needed to support OutdoorSTEM Learning activities?	The existence of rice fields and plantations as well as fields makes it easier to access and implement the Outdoor STEM Learning process.
	Risks and Challenges of Implementation	
14.	Do you feel there are certain risks in outdoor activities? If so, what do you think is the best way to manage those risks?	Yes, there are more risks when learning outdoors, such as the fear of dangerous animals or other dangerous things as the learning location. To handle these risks, of course, teachers must ensure a safe location for the learning place.
15.	What challenges do you expect will arise in the implementation of Outdoor STEM Learning? And how do you plan to manage those challenges?	The challenge that is expected to arise is the weather conditions, especially when it rains, students are more difficult to control or regulate when outdoors (many distractions). For this challenge, teachers must be extra in supervising students when learning outdoors, teacher must make their students more focused on learning so that their focus is not easily distracted.

No.	Aspect and Questions	Answer
	Long-term Impact	
16.	How do you think Outdoor STEM Learning can have a long-term impact on students' understanding of biology?	Students can have a pleasant experience when learning outdoors. The existence of fun learning will certainly have an impact on students' understanding of biology learning and the existence of hands-on practice in the field provides students with experiences that will always be remembered for a long time.
17.	Do you believe that students' STEM skills will improve through the implementation of outdoor learning applications?	Yes, because students can collaborate, think critically, and cooperate with their peers directly based on the conditions in the environment.
18.	How do you see the implementation of Outdoor STEM Learning contributing to the environmental awareness of students?	The application of Outdoor STEM Learning can contribute to students' environmental awareness, because learning in an environment that involves students directly in contextual problems can encourage students' awareness to provide direct solutions to problems experienced in the environment.
19.	How can outdoor activities prepare students to face the challenges of the 21st century, such as critical thinking and collaboration?	Outdoor STEM Learning activities can prepare students to face the challenges of the 21st century, such as critical thinking skills and collaboration, students can design and create innovations in learning as one of the solutions to a problem done with group friends. One of the innovations that can be used as a solution in learning in this school is the manufacture of water filters, this innovation is following environmental conditions in this area because of the difficulty of accessing clean water so the manufacture of water filters by students can be beneficial to daily life.
20.	Are you interested in applying outdoor learning in teaching biology? Why?	Interested, because it has never been applied in learning so it needs to be tried.
21.	What are your expectations regarding the implementation of Outdoor STEM Learning in schools?	It can be applied and give a good and memorable experience to students.

Table 2. Results of Interviews with High School Biology Teachers in Jakarta

No.	Aspect and Questions	Answer
	Experience and Skills of Teacher	
1.	How has your experience been teaching biology in the classroom?	The speaker had an enjoyable experience teaching Biology in class, despite all the

No.	Aspect and Questions	Answer
		challenges.
2.	So far in learning biology, what learning models are often used?	The Inquiry, PBL, and PJBL learning models are still frequently used by the speakers.
3.	How do the students respond to that learning?	Students respond to it very well and find it enjoyable.
4.	Have you previously known or heard of the STEM-based Outdoor Learning teaching model?	The speaker has experience integrating STEM but with only a few subjects and has never encountered Outdoor Learning.
5.	What is your opinion on the importance of outdoor learning for biology subjects?	This becomes very important because outdoor learning can foster the constructivism of students.
6.	Do you feel you have sufficient skills to implement Outdoor STEM Learning?	The skills possessed by the resource person still need reinforcement and expert guidance.
7.	What type of training do you need to help you implement Outdoor STEM Learning?	Implementation training demonstrated directly seems to be effective.
	Student Involvement	
8.	To what extent do you see students engaged in biology learning currently?	Students in Biology Learning are always actively involved, whether in discovering, discussing, collaborating, or thinking critically.
9.	What do you think can improve learner engagement in biology lessons?	Problem-based discussions, and the use of aids such as e-modules, applications, or maximizing resources available in the school environment to foster the 4Cs (21st-century skills) in students.
	Curriculum and Learning Materials	
10.	Do you think the current biology curriculum allows for the implementation of Outdoor learning?	This is possible, because with the implementation of the current curriculum, namely an independent curriculum, teachers have the freedom to explore CP.
11.	What topics in biology do you think can be taught better through outdoor activities?	Materials that can be taught include environmental pollution, ecosystems, biodiversity.
	Resources and Facilities	
12.	Does your school have sufficient resources or facilities to support outdoor learning?	There is still a need to strengthen resources or facilities to support outdoor learning.
13.	What resources and facilities do you think are needed to support OutdoorSTEM Learning activities?	There needs to be an adjustment between objects or resources and the concepts taught following Biology learning.

No.	Aspect and Questions	Answer
	Risks and Challenges of Implementation	
14.	Do you feel there are certain risks in outdoor activities? If so, what do you think is the best way to manage those risks?	There are certainly risks involved because we are taking students outside the classroom, especially since the time required must exceed that of classroom learning, and the condition of the students can sometimes be difficult to manage when outside the classroom.
15.	What challenges do you expect will arise in the implementation of Outdoor STEM Learning? And how do you plan to manage those challenges?	The anticipated challenge that will arise is the difficulty in controlling the students, which can be addressed with the assistance of an observer or shadow teacher.
	Long-term Impact	
16.	How do you think Outdoor STEM Learning can have a long-term impact on students' understanding of biology?	Since it involves a great deal of knowledge, it will enable students to think critically and make their learning a valuable experience.
17.	Do you believe that students' STEM skills will improve through the implementation of outdoor learning applications?	It is believed that students' STEM skills will improve through the implementation of outdoor learning applications.
18.	How do you see the implementation of Outdoor STEM Learning contributing to the environmental awareness of students?	The experience gained by students in outdoor learning, which directly engages with the environment, can foster environmental awareness.
19.	How can outdoor activities prepare students to face the challenges of the 21st century, such as critical thinking and collaboration?	With the presence of outdoor activities, students will collaborate and think critically about real problems that they found.
20.	Are you interested in applying outdoor learning in teaching biology? Why?	Interested, although I have routinely implemented the STEM model in learning, I have never applied STEM to Outdoor Learning.
21.	What are your expectations regarding the implementation of Outdoor STEM Learning in schools?	Training for teachers should be conducted and can be implemented in schools.

Experience and Skills of Teacher

The results of interviews at two schools indicate that,during their teaching experience, the sources more frequently use PBL, PJBL, Inquiry-Based Learning, Jigsaw, and gallery walk models, because these learning models are the most commonly used. It is also not uncommon for the sources to conduct practical work in Biology lessons, which makes the students more active and enthusiastic in Biology learning. The informant stated that at their school, there was another Biology teacher who had conducted Biology lessons through Outdoor Learning but had not integrated the STEM concept. Conversely, the informant from

a high school in Jakarta had conducted STEM-based Biology lessons but had not integrated them into the Outdoor Learning teaching method. Both informants have just heard about the concept of Outdoor STEM Learning, which has not yet been implemented in either school. They both showed interest in the application of this learning method, as its implementation can hone students' constructivist skills.

Experience and Skills of a Teacher Teachers play a pivotal role in facilitating Outdoor STEM Learning by acting as guides and mentors in exploratory settings. Effective implementation requires educators to be proficient in both STEM concepts and outdoor activity planning (Rahmawati & Suryadi, 2019). Professional development programs focusing on curriculum mapping, risk management, and integrating digital tools can empower teachers to create meaningful outdoor learning experiences (Yakin, 2024; Triplett & Triplett, 2023). Moreover, prior studies emphasize the need for collaborative teacher networks and workshops that enable the sharing of resources and best practices (Sulaeman et al., 2023).

Constructivism is a theory that discusses how learners form knowledge through engaging learning experiences they encounter, thus encouraging learners to actively discover their own skills, knowledge, or technology (Sugrah, 2019). This is in line with what Manungki & Manahung (2021) stated in their journal that in its application, the Outdoor Learning Method invites students to experience learning directly outside the classroom, which can provide students with the opportunity to build meaning and impressions in their long-term memory. The statement supports the source's answer, that the concept of Outdoor Learning has its own urgency, such as developing students' constructivist skills.

Student Involvement

The urgency of this matter has created interest among the informants regarding the implementation of the Outdoor STEM Learning method. An informant from a high school in Banten stated that before it is applied on a large scale, teachers as facilitators must possess the skills or abilities to guide students. The informant also explained the need for a type of training for teachers, such as workshops that include direct practice, so that teachers understand the stages of implementing Outdoor STEM Learning. Since neither informant has experience in applying this type of learning, the skills in implementing Outdoor Learning among teachers still need strengthening and expert guidance. Therefore, further training is necessary. Teachers play an important role during the learning process, as expressed by Rahmawati & Suryadi (2019) in their journal, stating that teachers are no longer the sole source of information for their students. Instead, teachers now act as facilitators, helping the

class become more lively and active. This causes the teacher's teaching paradigm to shift from being teacher-centered to being student-centered.

Student engagement is a cornerstone of effective outdoor STEM learning. Interactive activities stimulate curiosity and motivation, encouraging students to take ownership of their learning (Son et al., 2017). Collaborative tasks enhance teamwork, communication, and critical thinking skills, aligning with 21st-century educational goals (Crompton, 2020; Triplett, 2023). Real-world problem-solving projects, such as creating water filtration systems or monitoring biodiversity, allow students to apply theoretical knowledge practically (Sulaeman et al., 2023). Moreover, reflective practices foster self-assessment and continuous improvement, reinforcing learning outcomes (Mernisa & Djukri, 2018).

Curriculum and Learning Materials

Both schools have views related to changes in the current curriculum, namely the independent curriculum, which is considered to support the Outdoor STEM Learning process. This is because in the independent curriculum, teachers have the freedom to explore Learning Outcomes (CP) where Barlian & Solekah (2022) revealed that the Learning Outcomes or CP in the independent curriculum is a series of knowledge, skills, and attitudes of students that are interrelated with a continuous process, which forms overall competence. In addition, the independent curriculum is also considered to have a flexible and varied learning style. This is in line with what was revealed by Sofia *et al.* (2024) where in the implementation of an independent curriculum, learning is transformed, which previously nuanced in the classroom can be discussed outside the classroom. Then he explained that students can interact more with the teacher, the learning atmosphere also becomes more comfortable, and with outing class, learning is not just an explanation from the teacher but also contributes to the character building of students.

According to Artika *et al.* (2023) learning in biology has a very strong and close relationship with the surrounding environment and the concept of ecology. The results of interviews related to Biology materials that can support Outdoor STEM Learning according to both high schools in Banten and Jakarta argue that a variety of materials can be taught in Outdoor STEM Learning such as materials about ecosystems, biodiversity, growth, and development, classification of living things, and environmental pollution. This is like what is conveyed by Suwardi (2021) where as part of STEM, science is the study of natural phenomena by making observations and measurements to provide an objective explanation of the ever-changing nature. Sofia *et al.* (2024) also argue that STEM is an approach that connects and implements various disciplines in STEM that focuses on problems that occur in

everyday life and can train students to apply the knowledge gained to events that occur in real life.

Resources and Facilities

Regarding the resources and facilities available in schools to support the implementation of Outdoor STEM Learning, each school has its differences. The school environment is one of the concerns in the implementation of Outdoor STEM Learning. According to Ariesandy (2021), Outdoor Learning is a method that utilizes environmental resources to create interesting and enjoyable learning experiences and overcome boredom for students during learning, because the material taught is experienced directly during activities outside the classroom, this helps students build meaning and deep impressions in memory, and by utilizing the environment, teachers invite students to learn directly in the field in a real and conceptual way. From the results of the interviews conducted, one of the high schools in Banten has sufficient resources and facilities to support because the location of the school is close to the open nature such as rice fields and plantations, and the existence of open areas to facilitate access and the process of implementing Outdoor STEM Learning. Meanwhile, one of the high schools in Jakarta believes that there is still a need for strengthening related to existing facilities and resources as well as adjustments to the concepts taught at school.

Access to resources and facilities significantly impacts the success of outdoor STEM programs. Schools with proximity to natural environments, such as parks or gardens, can leverage these spaces for hands-on learning (Ariesandy, 2021). Adequate funding is essential for equipment like sensors, data collection tools, and safety gear (Suwardi, 2021). Partnerships with community organizations and environmental agencies can supplement school resources, offering expert guidance and field trip opportunities (Harris & Lopez, 2022; Triplett & Triplett, 2023). Professional development workshops should also focus on maximizing existing resources and integrating low-cost alternatives for resource-constrained schools (Yakin, 2024).

Risks and Challenges of Implementation

The results of the interview with one of the high school biology teachers in Banten and Jakarta also provided information about the challenges faced and the potential impact on students in the implementation of Outdoor STEM Learning. A high school biology teacher in Banten stated that she has not integrated STEM in biology learning both indoors and outdoors. According to the resource person, one of the learning innovations that can be applied in the Biology material at the high school and is relevant to the biology material is the making of water filters, this innovation follows the environmental conditions in the area because of the

difficulty of accessing clean water so that the making of water filters by students can be beneficial to daily life. According to Sulaeman et al. (2023), students can directly analyze the interaction between living things and their environment through a simple water filter project, in addition to the selection of the project can design various efforts to prevent and overcome environmental pollution and climate change. Meanwhile, a high school biology teacher in Jakarta said that he had implemented several STEM-based learning models, even though he had implemented these models, teachers still needed support to integrate STEM into Outdoor Learning. Teachers also emphasized the importance of training to understand the stages of implementing Outdoor Learning effectively. Training and support for teachers to integrate Outdoor STEM Learning can help improve teacher competence in learning, this is supported by the Yakin (2024) research, which says that providing training to teachers can improve the competence and quality of learning, the more training is carried out, the more training teachers will have a wide range of competencies and have an impact on improving the development of learning quality.

In the implementation of Outdoor STEM Learning, teachers said that some challenges and risks can occur when learning takes place, such as uncertain weather, lack of focus of students in learning, and dangerous field conditions, the existence of these risk challenges needs to be managed properly. Teachers must carry out extra supervision and ensure a safe location to mitigate any risk to learning. According to the resource person, the use of observers or shadow teachers can also be a solution to help control students during outdoor activities. Research by Istiqomah & Lailasari (2024), said that there are several inhibiting factors found when learning outdoors, which are the weather factors or outdoor situations and classroom management becomes more difficult. Weather factors can affect outdoor learning, especially when the rainy season teachers are unable to conduct outdoor learning. Teachers can overcome these problems by preparing other learning models if outdoor learning cannot be carried out. Another risk experienced when implementing outdoor learning is the difficulty of teachers in organizing, managing, and supervising students in outdoor learning. In its implementation, it also sometimes exceeds the predetermined learning deadline (Sari *et al.,* 2023). In overcoming students who have difficulty focusing on learning, can be handled by creating groups to make teacher supervision easier. As for the learning time that exceeds the lesson hour limit, teachers can overcome it by making a mature concept and planning the implementation time according to the lesson hours so that the implementation is more effective and does not take other learning time (Istiqomah & Lailasari, 2024).

While Outdoor STEM Learning offers numerous benefits, it also presents logistical and safety challenges. Teachers must account for unpredictable weather, student supervision, and resource limitations (Istiqomah & Lailasari, 2024). Effective planning, including risk assessments and safety protocols, is crucial to mitigating these challenges. Incorporating shadow teachers or assistants can enhance classroom management during outdoor activities (Cintami & Mukminan, 2018). Additionally, aligning outdoor lessons with curriculum standards and ensuring adequate funding for materials remain persistent challenges (Suwardi, 2021).

Long-term Impact

Both schools agreed that Outdoor STEM Learning has the potential to improve students' understanding of biology topics and STEM skills. Outdoor learning allows learners to learn from hands-on experience, which has a positive impact on their long-term memory of the concepts being taught. This is supported by the research of Mernisa & Djukri (2018) which states that there is an increase in students' understanding of concepts in learning by applying Outdoor Learning through direct learning experiences with learning materials. Students are more active, able to build social interaction with their friends, strengthen teamwork, hone sensorimotor skills, and make biology learning more interactive and meaningful. The integration of STEM in outdoor learning can improve students' skills in analyzing and solving problems that occur in daily life, the existence of problems that occur in the environment can encourage students to think critically regarding the right solutions or handling provided with the STEM skills that students have (Ritonga & Zulkarnaini, 2021).

The application of Outdoor STEM Learning can increase students' environmental awareness by involving them directly in relevant contextual issues and can encourage student constructivism. According to Cintami & Mukminan (2018) in his research, outdoor learning is more effective in fostering an attitude of caring for the environment. This attitude can be manifested through verbal expressions or real actions, the attitude of caring for the environment reflects actions that arise from students' understanding of the importance of protecting the environment. Student constructivism is a theory that gives students the freedom to think, as well as encourages students to apply the theories they have learned to their daily lives (Suparlan, 2019). This can be encouraged through the application of Outdoor Learning because in the process students can find new information in learning, and then be able to solve problems that they find directly in the environment according to the topics that have been studied (Izzati *et al.,* 2023).

Overall, both schools showed strong interest in developing Outdoor STEM Learning further. With training support for teachers and improved facilities, the potential of outdoor learning can be maximized to create a more meaningful and memorable learning experience for students. This learning is expected to prepare students for the challenges of the 21st century by improving their critical thinking and collaboration skills. Skills and abilities in problem-solving, communicating, character-building, and rational thinking require critical, structured, logical, and innovative ways of thinking. These skills are especially important in an age that is increasingly filled with technology, such as in terms of selecting and managing information and interacting effectively (Alvionita et al., 2023). Outdoor learning has a positive impact on students' critical thinking skills, in Putri's (2023) research, outdoor learning often involves hands-on activities, active participation, collaboration, deep understanding of concepts, and problem-solving that can foster students' critical thinking skills. The integration of STEM in outdoor learning can be the foundation for learning innovations aimed at developing 21st-century skills, that is 4C skills (Communication, Collaboration, Critical Thinking and problem-solving, and Creative and Innovative) (Suwardi, 2021). In facing the challenges of the 21st century, in addition to the 4C skills, students also need to be prepared with the 6C skills, that is Collaboration, Communication, Creativity and Innovation, Critical Thinking and Problem Solving, Computational, and Compassion (Siswono et al., 2023).

Based on the results of interviews and literature review, it can be stated that it is important for schools to explore and implement Outdoor STEM Learning effectively. Through collaboration between teachers and the school in providing adequate facilities and training, it is hoped that the learning process can be optimal. This will have a positive impact not only on students' academic understanding but also on the development of their character as individuals who care about the surrounding environment.

The integration of STEM activities in outdoor environments has been shown to foster long-term retention of concepts and build environmental awareness among students (Mernisa & Djukri, 2018). By participating in hands-on projects, students develop critical thinking, collaboration, and problem-solving skills that prepare them for future academic and career pursuits (Ritonga & Zulkarnaini, 2021; Triplett, 2023). Moreover, outdoor learning experiences create meaningful connections to real-world issues, promoting lifelong environmental stewardship (Cintami & Mukminan, 2018).

CONCLUSION

Based on the needs analysis through interviews that have been conducted in two schools in Banten and Jakarta Provinces, Outdoor STEM Learning is considered to be able to improve

students' understanding of Biology materials at school, build awareness of the surrounding environment, help students in 21st-century abilities and skills, and the ability of students' constructivism through direct learning experiences in nature. Each school expressed a deeper interest and curiosity regarding the implementation of Outdoor STEM Learning by showing the potential and support of environmental facilities and resources for the implementation of Outdoor STEM Learning in schools as well as the independent curriculum currently implemented. Various challenges such as lack of teacher training and supportive facilities. Therefore, there is a need for collaboration between teachers schools, and related parties so that the implementation of Outdoor STEM Learning can run optimally and as expected.

The findings underscore the transformative potential of Outdoor STEM Learning in biology education. Despite facing implementation challenges, the approach provides students with experiential learning opportunities that enhance conceptual understanding, problem-solving abilities, and environmental responsibility. Recommendations for supporting this model include investing in teacher training, improving outdoor facilities, and fostering partnerships with environmental organizations. Future research should explore scalable models for integrating Outdoor STEM Learning across diverse educational contexts, ensuring accessibility and long-term sustainability (Spencer & Triplett, 2024).

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