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Research Trends in Outdoor Learning in Science Education: A PRISMA-Based Systematic Literature Review (2021–2025)

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ABSTRACT

This study aims to examine research trends and synthesize key findings related to the implementation of outdoor learning in science education through a Systematic Literature Review (SLR) approach. The literature search was conducted using the Scopus database and focused on publications published between 2021 and 2025. The initial search retrieved 197 records, which were subsequently screened in accordance with the PRISMA guidelines using predefined inclusion and exclusion criteria, resulting in 12 studies being selected for further analysis. Based on the descriptive mapping and synthesis of the selected studies, the findings suggest that outdoor learning may enhance students' conceptual understanding, engagement, learning motivation, and several aspects of thinking skills, although direct evidence regarding critical thinking remains limited. The reviewed studies suggest that outdoor learning may support conceptual understanding, engagement, motivation, and some aspects of thinking skills, although direct evidence on critical thinking remains relatively limited. Mixed methods emerged as the most frequently used research approach, followed by qualitative and quantitative methods. The review further identifies underexplored areas, particularly technology integration and the implementation of outdoor learning across diverse educational contexts, highlighting important opportunities for future research.

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1. INTRODUCTION

In contemporary education, science learning is no longer limited to the mastery of concepts but increasingly emphasizes students' active participation in scientific processes. [1]. However, instructional practices that rely predominantly on in-class activities and lecture-based approaches tend to create a sense of monotony, ultimately diminishing students' interest in learning [2]. According to [3], the challenges experienced by learners may arise both consciously and unconsciously, encompassing psychological and social

aspects as well as factors related to the learning process. This condition highlights the need for instructional innovation that can provide more contextual and meaningful learning experiences. Educators, particularly science teachers, play a vital role in creating meaningful learning experiences that equip students with the knowledge and skills needed to face the ever-changing challenges of everyday life [4]. One relevant approach and learning experience is outdoor learning, which utilizes the environment as a learning resource, allowing learners to interact directly with real-world phenomena. According to Novljan and Pavlin [5], outdoor learning is defined as an educational process conducted outside the physical boundaries of the school. In practice, outdoor learning encompasses various educational settings, including field visits, school gardens, museums, natural environments, and community-based learning activities, providing students with opportunities to engage directly with authentic scientific phenomena and learning experiences that are relevant to real-world contexts.

Outdoor learning is closely associated with Kolb's Experiential Learning Theory, which proposes that understanding is developed through concrete experiences followed by reflection, conceptualization, and active application. This process enables students to construct meaningful understanding based on their direct experiences [6].

Several studies indicate that the implementation of outdoor learning provides various positive contributions to science education. According to Zulfirman [7], learning activities conducted outside the classroom can serve as an alternative to reduce students' boredom during the learning process. In addition, [8] points out that this approach is increasingly being adopted as a form of instructional innovation. Findings from [9] show that outdoor learning activities not only affect students' physical and mental aspects but also enhance their engagement in learning. This is consistent with studies [10], [11], and [12], which emphasize that direct interaction with the environment helps students understand concepts more concretely while also developing critical thinking and problem-solving skills.

Although numerous studies have explored the implementation of outdoor learning in science education, most have focused on specific contexts or particular learning outcomes using diverse research approaches, participants, and perspectives. Consequently, the existing findings remain fragmented and do not yet provide a comprehensive understanding of research developments in this field. Moreover, systematic investigations that comprehensively present publication trends, research methodologies, areas of focus, and key findings through a Systematic Literature Review approach remain relatively limited, particularly for more recent publications. Therefore, a comprehensive synthesis is needed to identify current research trends, recognize existing gaps, and provide direction for future research.

The period from 2021 to 2025 was selected because it represents the most recent stage of research development, characterized by a growing emphasis on contextual, experiential, and environment-based learning approaches in science education. Analyzing publications from this period is expected to provide up-to-date insights into current research patterns as well as emerging directions in outdoor learning. To address this issue, the present study employs a Systematic Literature Review (SLR) approach based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. This

approach enables the processes of literature searching, selection, and synthesis to be conducted in a systematic and transparent manner [13]. This is in line with the objectives highlighted by [14] and [15], who state that a systematic review can identify and evaluate all empirical evidence that meets predetermined inclusion criteria in order to answer research questions. Through this method, various dispersed research findings can be integrated, resulting in a more comprehensive understanding of the development of outdoor learning research in science education [16].

Based on the above discussion, this study aims to analyze the development of outdoor learning research in science education using a PRISMA-based SLR approach. To achieve this objective, the study is guided by several research questions as follows:

1. What are the publication trends of research on outdoor learning in science education?
2. What research methods are most frequently used in studies on outdoor learning in science education?
3. What research topics are most dominantly addressed in studies related to outdoor learning in science education?
4. What are the main findings regarding the implementation and impact of outdoor learning in science education?

The findings of this study are expected to provide a comprehensive overview and serve as a reference for the development of environment-based science learning in the future.

2. METHOD

2.1 Research Design

This study employs a systematic literature review (SLR) approach to examine various studies related to outdoor learning in science education. This approach was selected to obtain a systematic, structured, and comprehensive overview of research trends, methods, and relevant findings. This study is categorized as a descriptive qualitative study based on literature analysis, focusing on the synthesis of previous research findings. Through this approach, researchers are able to identify patterns, trends, and relationships among findings in the study of outdoor learning in science education. This review was conducted using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework as a methodological guideline to support the processes of literature searching, screening, eligibility assessment, and study selection systematically and transparently. The use of this framework enhances the consistency and reproducibility of the review by providing a structured procedure for selecting studies that are aligned with the research objectives.

2.2 Time and Research Setting

This study was carried out on March 9, 2026, through an online literature search using the Scopus database. The search was conducted at 14:38 WIB using a computer connected to the internet.

2.3 Data Sources and Selection Criteria

The search process was conducted using the following search string: TITLE-ABS-KEY ("outdoor learning" AND "science education"). The search strategy was focused on the keywords “outdoor learning” and “science education” to ensure that the selected studies explicitly examined outdoor learning within the context of science education. Related terms, such as outdoor education, fieldwork, field trips, place-based learning, nature-based learning, environmental learning, school gardens, museum learning, and learning outside the classroom, were not included in order to maintain the specificity and consistency of the review. Therefore, the findings should be interpreted within the scope of the predefined search strategy. The search was limited to articles published between 2021 and 2025 in order to represent recent research developments over the last five years, although the search itself was carried out in 2026. Despite being conducted in 2026, this limitation was applied because publications from that year were still limited and not sufficiently representative, allowing the study to focus on more stable and relevant trends.

Furthermore, Scopus was selected as the primary data source because of its extensive coverage of high-quality, peer-reviewed journals and its rigorous indexing standards in the fields of science and education. Its comprehensive metadata also supports a systematic and transparent process of literature searching and selection. Although relying on a single database may limit the inclusion of potentially relevant studies, this decision was made to ensure consistency in the search strategy and to maintain uniform standards for identifying and selecting the literature included in the review.

The inclusion and exclusion criteria applied in the article selection process are presented in Table 1 below.

Table 1. Inclusion and Exclusion Criteria in Article Selection

Aspect	Inclusion Criteria	Exclusion Criteria
Publication type	Journal articles	Conference proceedings, books, and review articles
Year of publication	2021-2025	Outside this range
Language	English	Other than English
Field of study	Science education	Outside science education
Access	Open access or full text	Full text not available
Research focus	Directly addresses outdoor learning	Does not focus on outdoor learning

The inclusion criterion requiring open-access or full-text availability was applied to ensure comprehensive assessment and accurate data extraction from each study. Although this criterion may have excluded some relevant subscription-based articles and introduced potential selection bias, it was adopted to maintain the transparency and reproducibility of the review process.

2.4 Research Procedure

The research procedure followed the stages outlined in the PRISMA framework, including identification, screening, eligibility assessment, and final selection of articles. The

initial search yielded 197 articles. During the first screening stage, 74 documents were excluded because they were not categorized as journal articles, leaving 123 articles.

The next stage involved selection based on topic relevance, where 95 articles were excluded for not specifically addressing outdoor learning within the context of science education. As a result, 28 articles met the initial criteria.

Subsequently, a full-text assessment and more in-depth content evaluation were conducted, leading to the exclusion of 16 articles due to incomplete access or lack of direct relevance to the research focus. This process resulted in 12 articles that were used as data sources in this study. The relatively limited number of articles reflects the application of strict selection criteria to ensure data quality and relevance.

The study selection process was conducted by the author through a stepwise assessment of titles, abstracts, and full texts based on predefined inclusion and exclusion criteria. These criteria were applied consistently to ensure transparency and methodological consistency. As the review was performed by a single reviewer, inter-rater reliability measures, such as Cohen's kappa, were not applicable.

2.5 Data, Instruments, and Data Collection Methods

Data were collected through a documentation technique by searching for and downloading articles that met the selection criteria. Data were extracted using a predefined data extraction form. The extracted information included the publication year, research category and method, participants or educational level, research focus, and key findings of each included study. These data were systematically identified from the title, abstract, and full text of the selected articles and organized according to the objectives of the review to support the descriptive mapping and synthesis of the analyzed literature. The use of predefined extraction categories helped ensure consistency throughout the review process.

2.6 Data Analysis Methods

Data analysis was carried out descriptively using the SLR approach by organizing the data into several categories, including publication trends, research methods, and main research focus. Furthermore, interpretation was conducted to identify patterns and trends related to outdoor learning research in science education.

Keyword co-occurrence analysis was conducted using VOSviewer to examine the relationship among keywords extracted from selected Scopus-indexed articles. This method applies a co-occurrence approach combined with association strength as the normalization technique, which is the default setting in VOSviewer.

The analysis was used to identify key themes and research trends related to outdoor learning in science education. The resulting network visualization consists of seven main terms that represent the core thematic structure of the dataset.

In addition, a synthesis process was performed to summarize the main findings into broader themes, resulting in a more structured understanding of outdoor learning research in science education. The analysis not only focuses on reporting the data but also on interpreting the meaning of the patterns identified.

The results of the analysis are presented in a systematic narrative form, while the article selection process is illustrated through a diagram in Figure 1 based on the PRISMA framework.

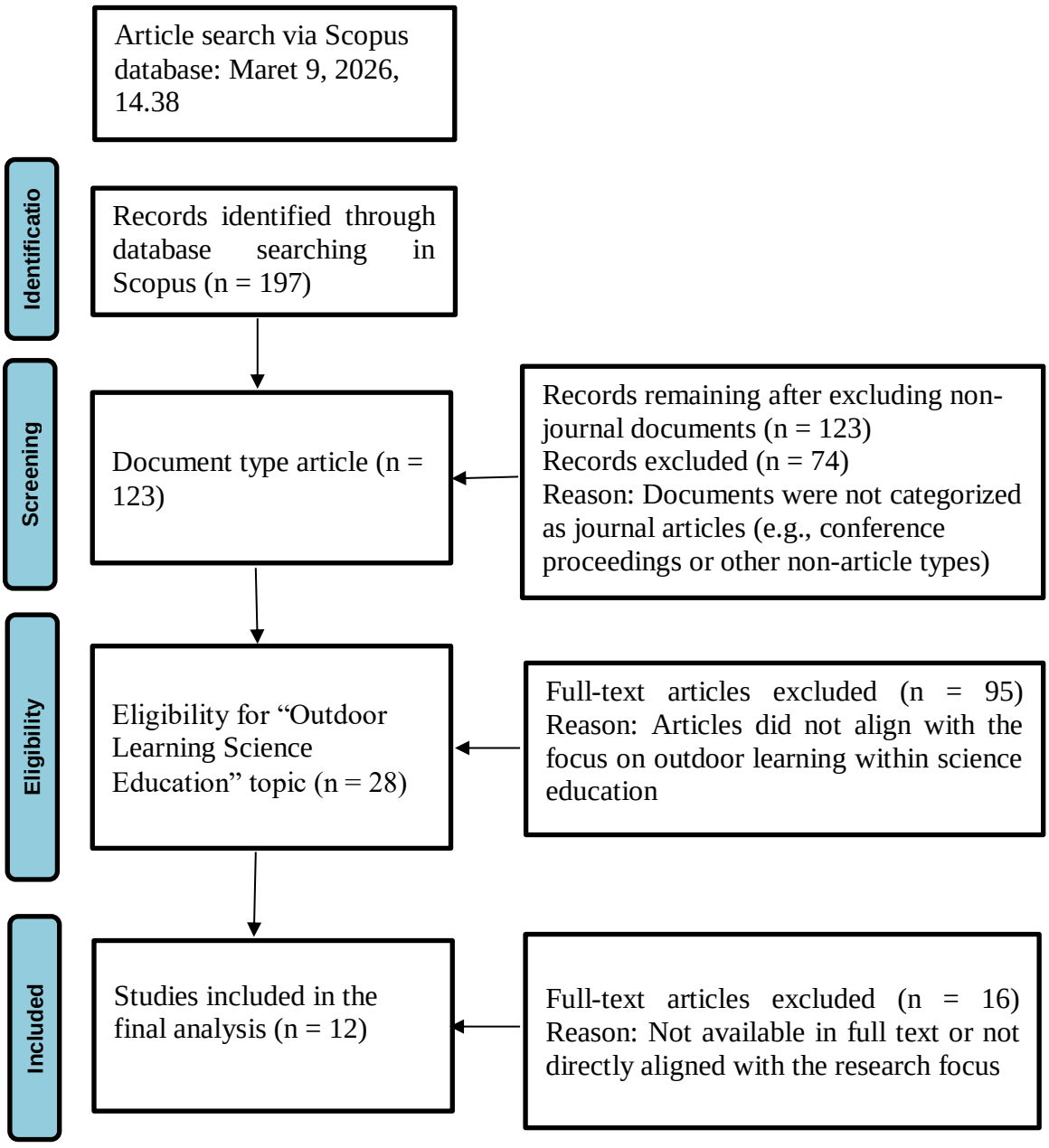


Figure 1. The Systematic Literature Review Process Based on the PRISMA Framework

3. RESULTS AND DISCUSSION

The findings of this study focus on the analysis of 12 articles identified from the Scopus database related to outdoor learning in science education. These articles were obtained through a systematic process of literature searching and selection, following the PRISMA stages and the predefined inclusion criteria. After the selection process was completed, the next step involved analyzing several key aspects of the selected articles. The analysis included the distribution of publications based on the year of publication, the

research methods used in each study, and the research focus addressed in each article. In addition, this study also examined the findings of each article to gain a more comprehensive understanding of how outdoor learning is implemented and studied in the context of science education. Through this analysis, the study is expected to provide a more comprehensive understanding of the development and trends of outdoor learning research in science education.

Table 2. Characteristics of the Analyzed Research Articles

Author	Article Title	Research Method	Main Findings	Recommendations
Telli,S. (2025)	Exploring the Preservice Teachers' Work to Label the Plants in the Faculty Garden	Qualitative	Plant labeling activities enhance the knowledge and confidence of preservice science teachers in outdoor learning.	It is recommended to integrate campus green spaces into science teacher education.
Pedonti, S., Becker, D.R., Watson, M.K., Grist, C.L. (2025)	Testing Rural Early Educators Attitudes toward Children's Outdoor Recreation in Nature and Science: a new framework for exploring early educators' situated science teaching	Quantitative	Teachers' values toward outdoor activities influence their perceptions of the difficulty of teaching science, with rural teachers showing greater engagement	It highlights the relationship between attitudes toward nature, outdoor learning, and science practices within a STEM framework.
Walshe, N., Perry, J., Healy, G. (2025)	Student perspectives on climate change and sustainability education in England: experiences and expectations	Mixed Methods	Students learn about climate change and express a preference for more practical and outdoor-based learning.	It is recommended to provide contextual learning through field activities and environmental projects.
Kesler, M., Kaasinen, A., Kervinen, A.(2024)	Teaching science Outdoors: Supporting preservice teachers' skill development with the help of available mobile applications	Mixed Method	Preservice teachers recognize that outdoor learning contributes to increased motivation and improved teaching skills.	It is recommended to integrate mobile applications into outdoor blended learning.
Susman, K., Vosnjak, M., Pavlin, J. (2024)	Evaluating the Development of Preservice Primary School Teachers' Competences in the Context of a Student-Centred Science Visits Course	Mixed Methods	Outdoor learning activities increase student engagement and strengthen their ability to design science field visits.	Strengthen the curriculum and enhance the assessment of students understanding of scientific concepts.
Photo, P. (2024)	Exploring the impact of zoological garden visits on science learning in primary school: Acknowledging and	Qualitative	Outdoor activities enhance student engagement and the ability to design science visits.	It is recommended to strengthen the curriculum and improve the assessment of

Author	Article Title	Research Method	Main Findings	Recommendations
	transforming prior knowledge via outdoor learning			science conceptual understanding.
Milne, L., Cheng, M.M.W., Prebble, J.G. (2024)	Drawing attention to attitudes toward scientists: Changes in 10-to 13-year-old students as a result of a GeoCamp experience in New Zealand	Quantitative	The GeoCamp program, which involves field activities with scientists, helps reduce stereotypes and improves students' understanding.	It is recommended to incorporate direct interaction with scientists in outdoor learning activities.
Jashari, H. (2023)	Some practices from STEM education and the incorporation of some SDG goals in the educational process in the Republic of North Macedonia	Quantitative	Coding activities using micro:bit devices, conducted both in the classroom and outdoors, enhance students' skills and interest.	It is recommended to implement coding activities in both classroom and outdoor learning settings to support the development of basic skills.
Mettis, K., Valjataga, T., Uus, O. (2023)	Mobile Outdoor Learning effect on Students' Conceptual Change and Transformative Experience	Mixed Methods	This study integrates location-based mobile applications into outdoor learning using a place-responsive pedagogy approach and the Teaching for Transformative Experience in Science (TTES) model.	It is recommended that technology-based outdoor learning design be adapted to students' needs and abilities and further developed to enhance engagement and promote deeper learning experiences.
Ayotte-Beaudet, J.-P., Chastenay, P., Beaudry, M.C., Desjarlais, E., Paquette, A. (2023)	Exploring the impacts of contextualised outdoors science education on learning: the case of primary school students learning about ecosystem relationships	Mixed Methods	Outdoor learning improves students' understanding of ecosystems, enhances investigative skills, and strengthens their connection with nature.	It is recommended to include activities that support concept generalization so that learning is not limited to local contexts.
Stagg, B.C., Dillon, J., Maddison, J. (2022)	Expanding the field: using digital to diversify learning in outdoor science	Mixed Methods	The #FieldworkLive program is well received by teachers. In addition, the use of video and live streaming expands access to fieldwork experiences while enhancing teachers' technology-based pedagogical skills.	It is recommended that the development of digital learning should improve participant interaction, provide better content differentiation, and ensure technical quality such as audio, connectivity, and

Author	Article Title	Research Method	Main Findings	Recommendations
				device support to create more effective learning experiences.
Abril-Lopez, D., Moron-Monge, H., Moron-Monge, M.C., Carrilo, M.D.L. (2021)	The learning to learn competence in early childhood preservice teachers: An outdoor and e/m-learning experience in the museum	Qualitative	Outdoor and e/m-learning experiences in museums enhance the learning competence of preservice teachers.	It is recommended to design museum visits using an inquiry-based approach supported by technology.

3.1. Results

RQ1: What are the publication trends of outdoor learning research in science education?

To address RQ1, an analysis was conducted on the distribution of publication years from the 12 selected articles. The results of this analysis are presented in Figure 2, which illustrates the number of outdoor learning research publications in science education during the period 2021-2025.

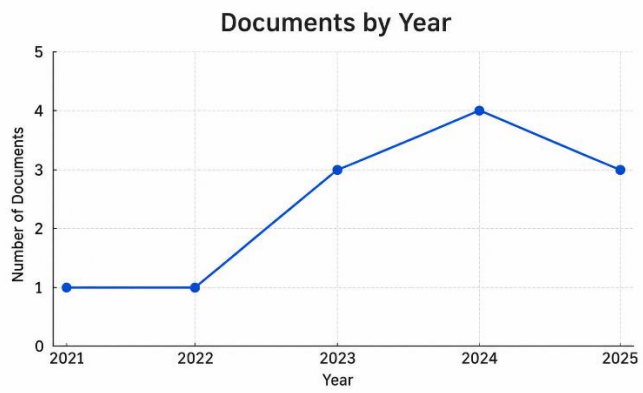


Figure 2. Number of Outdoor Learning Research Publications in Science Education by Year

Based on Figure 2, the publication trend shows a fluctuating pattern but generally tends to increase. In 2021 and 2022, the number of publications was relatively low, with only one article in each year. An increase began to appear in 2023 with three articles, reaching its peak in 2024 with the highest number of publications. In 2025, the number of publications slightly declined, but it remained higher than in the earlier years.

RQ2: What research methods are most frequently used in studies on outdoor learning in science education?

To address RQ2, an analysis was conducted on the research methods used in the 12 selected articles. The proportion of research methods is presented in Figure 3.

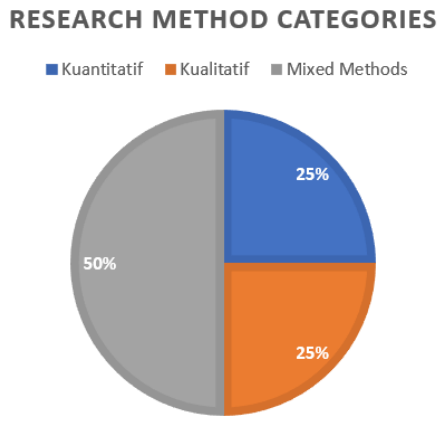


Figure 3. Proportion of Research Methods in Outdoor Learning Studies in Science Education

Based on Figure 3, the mixed methods approach is the most frequently used method in outdoor learning research, followed by qualitative and quantitative approaches. Out of the 12 articles, six studies applied mixed methods, while three used qualitative approaches and the remaining three employed quantitative methods. The dominance of mixed methods suggests that researchers combine quantitative and qualitative data to achieve a more comprehensive understanding of the implementation of outdoor learning in science education. This approach allows evaluation not only of learning outcomes but also of students' learning processes and experiences in greater depth.

For example, studies by [17] and [18] applied mixed methods to assess students' learning experiences while also measuring learning outcomes. Study [19] employed a quantitative survey to examine the relationship between teachers' perceptions of children's outdoor activities and factors such as perceived costs and beliefs about science learning, including differences between rural and urban contexts. On the other hand, qualitative studies such as those conducted by [20] and [21] focus on exploring learning experiences in greater depth, however, their number remains relatively limited compared to mixed-methods approaches.

Overall, these findings indicate that outdoor learning research tends to combine the measurement of learning outcomes with the exploration of learning processes. However, in-depth qualitative approaches still offer significant opportunities for further development, particularly in understanding the dynamics of students' interactions with their learning environment and how these experiences shape their conceptual understanding of science more holistically.

RQ3: What research topics are most dominantly addressed in studies related to outdoor learning in science education?

To identify the most dominant research topics in outdoor learning within science education, a keyword co-occurrence analysis was conducted using VOSviewer software. This analysis aims to map the relationships between concepts that frequently appear in scientific publications related to outdoor science learning. The mapping results are

visualized in the form of a network, illustrating the connections among keywords based on their frequency of occurrence and their relationships within the analyzed articles.

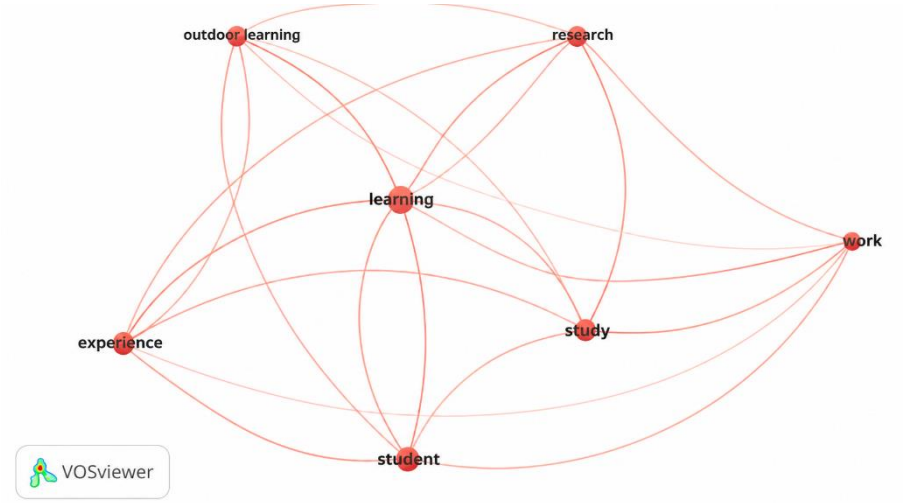


Figure 4. Network Visualization of Keywords in Outdoor Learning Research in Science Education

Based on the results of the article analysis and mapping using VOSviewer, research topics on outdoor learning in science education tend to be centered on the learning process. This is reflected in the dominance of keywords such as *learning*, *student*, and *experience*, which show strong interconnections with one another. These findings indicate that outdoor learning research is more focused on how learning experiences outside the classroom shape students' understanding, rather than solely measuring learning outcomes.

Although the keyword network provides an overview of relationships among frequently occurring terms, a further review of the selected studies revealed several recurring research themes. These themes are summarized in Table 3.

Table 3. Dominant Research Themes Identified in Outdoor Learning Studies

Research Theme	Number of Studies
Preservice Teacher Education	4
Technology-Supported Outdoor Learning	4
Student Engagement and Motivation	4
Conceptual Understanding	3
Environmental and Sustainability Education	3

Table 3 indicates that research on outdoor learning in science education primarily addresses preservice teacher education, technology-enhanced outdoor learning, student engagement and motivation, conceptual understanding, and environmental sustainability education. Collectively, these themes highlight the potential of outdoor learning to improve science learning outcomes while enriching students' learning experiences and supporting teachers' professional development.

RQ4: What are the main findings regarding the implementation and impact of outdoor learning in science education?

The synthesis of the analyzed articles indicates that the implementation of outdoor learning in science education produces a range of impacts, which can be grouped into several main themes.

1. Impact on Learning Outcomes and Conceptual Understanding.

   Most studies indicate that outdoor learning contributes positively to improving learning outcomes and students' understanding of scientific concepts. Learning activities conducted in real-world environments allow students to interact directly with the objects and phenomena being studied, making abstract concepts easier to comprehend. These findings are consistent with studies [22] and [18], which show that environment-based learning experiences can promote conceptual change and strengthen students' understanding. In addition, the study by Photo also confirms that outdoor learning can help students correct misconceptions through direct observation.

2. Impact on Engagement and Learning Motivation

   In addition to cognitive aspects, outdoor learning also contributes to increasing students' engagement and learning motivation. Learning activities conducted outside the classroom tend to be more exploratory and provide opportunities for students to actively participate in the learning process. This is reflected in study [17], which shows that students prefer more contextual and interactive learning experiences, including those involving outdoor activities. Similar findings are also reported in [23] and [24], indicating an increase in participation and engagement in environment-based learning.

3. Impact on Thinking Skills and Learning Experience

   Several studies also suggest that outdoor learning has the potential to develop students' thinking skills, particularly through deeper and more contextual learning experiences. Direct interaction with the environment encourages students to observe, interpret data, and relate concepts to real-life situations [25] [26]. However, studies that specifically focus on critical thinking skills remain relatively limited, indicating that this aspect has not yet become a primary focus in existing research.

4. Challenges in the Implementation of Outdoor Learning

   Despite the various benefits offered, the implementation of outdoor learning also faces several challenges. One influential factor is teachers' attitudes and perceptions toward outdoor learning. Study [19] shows that teachers' values and beliefs about nature-based activities influence their teaching practices. In addition, differences in context, such as rural and urban environments, also affect the ease of implementing outdoor learning. This indicates that the success of outdoor learning is determined not only by instructional design but also by contextual factors and the readiness of educators.

5. Implications for Preservice Teacher Education

   Several studies highlight that outdoor learning also has important implications for the development of preservice teachers' competencies. Learning experiences outside the classroom can enhance their confidence as well as their ability to design contextual learning. This is evident in studies [21] and [27], which show that direct involvement in environment-based activities helps preservice teachers understand how the environment

can be utilized as a learning resource. In addition, [28] emphasizes that educators need to develop their competencies and view challenges as opportunities continuously. Educators should be able to manage ongoing developments rather than be controlled by them. Therefore, improving competencies becomes essential, particularly in line with the application of contextual earth science and the demands of modern development. Thus, outdoor learning not only impacts students but also plays a role in shaping the pedagogical readiness of future teachers [29].

3.2. Discussion

The increase in the number of publications, particularly during the 2023-2024 period, indicates a shift in attention within science education research toward more contextual learning approaches. This trend suggests that outdoor learning is increasingly viewed as a relevant strategy for linking scientific concepts with students' real-life experiences. This is consistent with the emergence of various studies that explore the implementation of outdoor learning in different contexts, such as the integration of technology in outdoor learning and the enhancement of environment-based learning experiences [23], [24], [20].

From a theoretical perspective, these findings are consistent with previous studies indicating that field-based learning methods, such as field trips, are effective in enhancing students' understanding of the environment through direct experience [30]. Through these activities, students not only connect theory with practice but also develop observation and analytical skills, while increasing their motivation and engagement in learning. Furthermore, students' active involvement in outdoor activities allows them to become participants in the learning process rather than merely recipients of information, which contributes to increased learning activity and the development of critical thinking skills [31].

Furthermore, the increase in publications during this period can be understood as a response to the demands of 21st-century learning, which emphasize the development of critical thinking, collaboration, and problem-solving skills [32]. Recent studies also indicate that learning outside the classroom can enhance students' motivation and encourage active participation in the learning process, while providing opportunities for students to interact directly with their surrounding environment. This interaction helps them understand natural objects and phenomena in a more concrete and contextual manner [33]. These findings further strengthen the position of outdoor learning as a relevant approach in addressing the needs of modern education.

The distribution of publications should be interpreted with caution. Although the number of studies increased between 2021 and 2024, the slight decline observed in 2025 does not necessarily indicate a decrease in scholarly interest in outdoor learning within science education. Since the article search was conducted in March 2026 and only included publications up to the end of 2025, some studies published during that year may not yet have been fully indexed in the Scopus database. In addition, only twelve articles met the inclusion criteria for this review. As a result, the identified pattern should be considered an indication of trends within the selected studies rather than a comprehensive representation of global research on outdoor learning in science education. Nevertheless, the reviewed articles

suggest growing attention to topics such as sustainability, environmental education, and contextual learning, reflecting the expanding scope of research in outdoor learning.

Furthermore, as shown in Figure 3, the tendency to use mixed-methods approaches in outdoor learning research indicates that researchers aim to obtain a more comprehensive understanding of the phenomena being studied. The combination of quantitative and qualitative data allows the analysis to go beyond learning outcomes, encompassing the processes and experiences encountered by students during learning activities. This is particularly important given that outdoor learning is experience-based, requiring approaches that can capture its complexity more holistically. This phenomenon is consistent with the view that mixed methods approaches offer advantages in educational research, as they enable the integration of numerical and narrative data simultaneously [34]. In addition, within the context of science education, this approach is considered effective for examining the relationship between learning outcomes and students' direct experiences in their learning environment [35]. Therefore, the dominance of this approach in outdoor learning research can be regarded as well justified.

On the other hand, the number of studies employing qualitative approaches remains relatively limited. However, according to [36], this approach has strong potential to explore students' learning experiences in greater depth and to provide valuable insights into the complex dynamics of educational environments, particularly in understanding how interactions with the environment shape students' conceptual understanding of science. Meanwhile, quantitative approaches are more frequently used to identify relationships between variables, but they tend to be less capable of explaining the learning process in a contextual manner.

Therefore, the dominance of mixed methods can be understood as an effort to combine the strengths of each approach. Nevertheless, there remains an opportunity to further develop more in-depth qualitative research, particularly in examining students' authentic learning experiences and their contribution to the development of a comprehensive understanding of scientific concepts.

A further theme emerging from the analyzed studies is the increasing use of technology in outdoor learning practices. Instead of serving as a substitute for outdoor experiences, technologies such as mobile applications, e-learning and m-learning platforms, digital fieldwork activities, and livestreaming are employed to enrich and broaden learning opportunities. Across the studies, these technologies were found to perform similar functions by supporting observation and documentation, and by connecting real-world outdoor experiences with more structured forms of learning. Consequently, technology-enhanced outdoor learning can help increase student engagement and foster deeper learning experiences. Nevertheless, research is relatively limited, indicating the need for further investigation across a wider range of educational settings and levels.

Furthermore, as shown in Figure 4, the keywords *learning*, *student*, and *experience* were the most frequently occurring terms in the network visualization. This finding suggests that studies on out-of-classroom learning in science education primarily emphasize students' learning experiences and their engagement with the surrounding environment. The pattern

is consistent with constructivist perspectives, which argue that knowledge is constructed through direct experience and active participation in learning activities [37], [38]. Similar observations have been reported by [39] and [40], who noted that out-of-classroom science learning provides opportunities for students to observe natural phenomena firsthand and apply scientific concepts in authentic contexts. These experiences help students relate classroom knowledge to situations encountered in everyday life.

From an educational perspective, the findings suggest that outdoor science learning should be carefully planned and aligned with curriculum objectives. Teachers need to consider learning goals, available time, safety procedures, and appropriate student preparation before conducting outdoor activities. Digital tools may also be incorporated to support data collection and document learning processes. At the same time, several challenges require attention, including weather conditions, students' safety, teacher readiness, school policies, transportation requirements, access to learning sites, and financial constraints. Addressing these factors is essential to ensure that outdoor learning can be implemented effectively and sustained over time.

The studies included in this review were conducted across a wide range of educational settings, involving participants from primary school students to early childhood educators and preservice science teachers. This diversity suggests that outdoor learning is implemented for different purposes depending on the educational context and target group. In school settings, outdoor learning is commonly used to strengthen conceptual understanding, encourage active participation, and provide learning experiences that are closely connected to real-life situations. In contrast, for preservice teachers, outdoor activities are more often designed to develop teaching competencies, support professional preparation, and enhance their ability to design learning experiences that make use of the surrounding environment. Therefore, the findings should be interpreted in relation to the specific characteristics and educational objectives of each context rather than being generalized across all groups.

On the other hand, the presence of keywords such as *study*, *research*, and *work* indicates that research in this field is still largely focused on exploring and implementing learning practices, both in formal education contexts and in professional development. However, there is no clear dominance of themes related to technology integration or specific approaches, suggesting that the direction of research remains relatively general and has not yet moved toward more specific innovation development.

These findings indicate that current research on outdoor learning in science education places greater emphasis on students' learning experiences and engagement. Nevertheless, there remains considerable opportunity to expand research in more diverse directions, such as the integration of technology, interdisciplinary approaches, and exploration across broader educational contexts. Based on the Scopus-indexed articles selected for this review and published between 2021 and 2025, research on outdoor learning in science education remains relatively limited in scope and is unevenly distributed across different topics and educational contexts. In addition, the relatively small number of studies examining technology integration, variations in educational contexts, and differences across educational levels highlights significant opportunities for future research development.

The findings indicating that environment-based science learning can enhance students' interest and knowledge highlight the importance of direct experience in the learning process. Students' engagement with the environment enables them to understand concepts more concretely, rather than solely at a theoretical level. This is consistent with *experiential learning* theory, which states that knowledge is constructed through direct experience [41].

Another limitation of this review relates to the search strategy employed. The search terms were specifically focused on outdoor learning and science education, therefore, studies using different terminology may not have been captured in the search results. As a consequence, some relevant publications may have been excluded from the final dataset.

Overall, outdoor learning has strong potential as an important approach in science education, as it enables the connection between concepts and real-world experiences. Therefore, future research should be directed toward developing more systematic and adaptive learning designs to provide a more significant contribution to science education practices.

4. CONCLUSION

The findings of this study indicate that publications related to outdoor learning in science education have shown an increasing trend in recent years, reflecting growing attention to context-based learning approaches (RQ1). Mixed methods emerged as the most dominant research approach, followed by qualitative and quantitative methods, highlighting the importance of understanding learning not only in terms of outcomes but also the processes involved (RQ2). Research focus tends to emphasize learning experiences, student engagement, and conceptual understanding in science (RQ3). Overall, the implementation of outdoor learning contributes positively to improving learning outcomes, motivation, thinking skills, and the pedagogical competence of preservice teachers (RQ4).

Overall, this study provides an overview of the current research landscape and addresses the objectives presented in the introduction by examining publication trends, research methodologies, research focuses, and the main findings on outdoor learning in science education.

From a theoretical perspective, this study contributes to reinforcing the understanding that direct experience is a key element in meaningful science learning, while also confirming the relevance of outdoor learning within the constructivist learning framework. Practically, these findings can serve as a reference for teachers and preservice teachers in designing learning activities that utilize the environment as a learning resource, thereby enhancing student engagement and conceptual understanding in a more contextual manner.

This study has several limitations. First, it relied solely on the Scopus database and included only open-access publications. In addition, the analysis was limited to the 12 Scopus-indexed articles that met the predefined selection criteria. Consequently, the findings should not be interpreted as representing the entire body of research on outdoor learning in science education but rather the specific studies included in this review. Furthermore, this study did not integrate bibliometric analysis with a comprehensive literature review. As a

result, it does not provide a broader perspective on the development of research in this field from a bibliometric standpoint.

Given these limitations, future studies are encouraged to include multiple databases and a larger number of articles to provide a more comprehensive overview of the field. Integrating systematic literature reviews with bibliometric analysis may also offer deeper insight into the development of research on outdoor learning in science education. In addition, further investigation is needed into the ways technology can be effectively integrated into outdoor learning to support science education.

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