

# ESD-Based Outdoor Learning in Animal Biosystematics Course: A Strategy to Improve Students' Understanding of Conservation

Saefudin <sup>a,1,\*</sup>, Anugrah Ayumaharani Widianingsih <sup>b,2</sup>, Fitri Husni Mardiyah <sup>b,3</sup>, Suhara <sup>b,4</sup>

<sup>a</sup> Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

<sup>b</sup> Faculty of Mathematics and Science Education, Universitas Pendidikan Indonesia, Bandung, Indonesia

<sup>1</sup> [saefudin1763@gmail.com](mailto:saefudin1763@gmail.com); <sup>2</sup> [anugrahayumaharani@upi.edu](mailto:anugrahayumaharani@upi.edu); <sup>3</sup> [fitrihusni@upi.edu](mailto:fitrihusni@upi.edu); <sup>4</sup> [suhara@upi.edu](mailto:suhara@upi.edu)



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## ABSTRACT

This study aims to explore the extent to which outdoor learning grounded in Education for Sustainable Development (ESD) enhances students' conceptual grasp of biodiversity, evolution, and conservation. Thirty-seven undergraduate biology education students participated in this study, which employed a quasi-experimental one-group pretest-posttest design in the Animal Biosystematics course. Data were collected using a standardized questionnaire and written cognition tests. The results showed a statistically significant improvement in students' posttest scores ( $M = 90.24$ ,  $SD = 4.98$ ) compared to their pretest scores ( $M = 81.29$ ,  $SD = 3.65$ ), with a significant effect  $t(36) = -25.049$ ,  $p < .001$ , Cohen's  $d = 2.17$ . The study of questionnaire responses revealed that over 88% of students had positive perceptions about the utilization of outdoor learning in four key areas: participation (who), learning content (what), learning environment (where), and instructional approach (how). Additionally, more than 67% of students stated they would be open to participating in future outdoor learning activities and planning that are based on ESD. Additionally, students stated that the educational experience raised their critical understanding of conservation and sustainability issues. These results imply that ESD-focused outdoor learning is an effective teaching method to promote ecological awareness and active student participation in biology classes with a sustainability focus.

## KEYWORDS

Animal,  
Biosystematic,  
ESD,  
Outdoor learning

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## 1. Introduction

Education for Sustainable Development (ESD) has become a globally recognized approach to integrating sustainability principles into learning, in line with the Sustainable Development Goals (SDGs) set by the United Nations in 2015. The goal of ESD is to provide learners with the knowledge, skills, and values that support social justice, economic development, and sustainable environmental preservation. In higher education, ESD is not merely a conceptual framework but a pedagogical imperative that requires deliberate integration into discipline-specific courses (Kioupi & Voulvoulis, 2019; Wu et al., 2024). In courses such as Animal Biosystematics and Evolution, this connection carries particular weight. Learning about biodiversity, how species are related, and how they adapt to their environments is closely tied to the conservation challenges that are central to the Sustainable Development Goals 4 and 15. Instead of just studying these concepts in a classroom, taking education for sustainable development outdoors allows students to have hands-on experiences with the natural world. This means they get to see the variety of living things up close, watch how species evolve in real ecosystems, and work on solving local conservation problems. By doing this, students connect what they learn in science class to the values and skills they need to take action and live sustainably, as shown in recent research (Neville et al., 2023; Wu et al., 2024). This approach helps students understand that conservation is not just an abstract idea, but something that requires practical action and community involvement.

Learning about the environment outside of a classroom can be really powerful. When students are close to nature, they get more interested in what they're learning and start to care more about the planet. This is what some researchers, like Könnel and his team, found out in 2025. They saw that when kids are learning outside, they become more passionate about taking care of the Earth. This makes sense, because when you're learning about something in the place where it actually happens, it's easier to

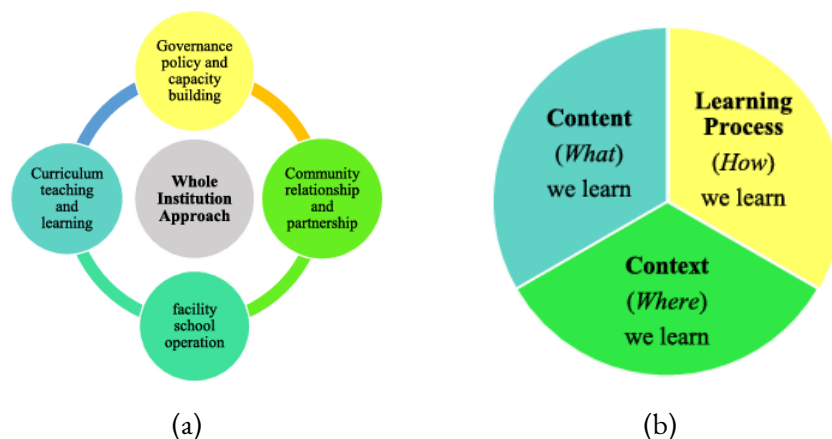
understand and remember. For example, learning about different species and how they evolved is more fun and meaningful when you're seeing them in person, rather than just reading about them. Some other researchers, like Haaland and Baklien, found that learning about biology and nature is more effective when you're actually out in the field, observing and naming the species you're learning about. A big review of studies by Wu and his team in 2024 found that spending time in nature is one of the best ways to help university students develop the skills they need to live sustainably.

Indonesia is in a unique spot when it comes to biodiversity and conservation. The country is home to around 17% of all species on Earth, which is a huge concentration of life. This makes Indonesia one of the most important countries in the world for biology. However, with this natural wealth comes a big responsibility, and the country's education system has not yet fully taken on this challenge. According to data from the IUCN, as of 2021, there are 189 animal species in Indonesia that are critically endangered, including mammals, birds, reptiles, and amphibians. This was reported by Purnama in 2024, and it shows just how fragile the biodiversity in Indonesia has become. The fact that so many species are at risk of disappearing forever is a serious concern. It's clear that Indonesia has a lot of work to do to protect its natural heritage. By educating people about the importance of conservation, the country can start to make a difference and ensure that its incredible biodiversity is preserved for future generations. This is not just a matter of saving animals and plants, but also of protecting the health of the planet and the well-being of the people who live there. Indonesia's natural wealth is a precious resource that needs to be cared for and protected.

What is most urgent for educators in this case is the remaining gap between the ecological richness and awareness of conservation students have. Research carried out in Indonesian education contexts has consistently found that students have textbook knowledge of biodiversity, but this knowledge is rarely put into real action in terms of commitment to conservation. Fajri et al. found that the conservation literacy of biology students was moderate, with significant deficiencies in their actual behavior and values, which are the most critical aspects for real-life conservation action (2025). A similar pattern was found in Pangsuma et al.'s (2024) study of Conservation Biology students, who demonstrated sufficient knowledge of facts but surprisingly low levels of engagement in conservation-oriented behaviors. Together, these findings suggest that the challenge in Indonesian conservation education is not simply one of knowledge transmission but of cultivating the dispositions and habits that turn awareness into action. These findings suggest that conventional classroom instruction is insufficient for building contextual understanding of the relationship between biodiversity and sustainability.

Furthermore, technological developments and global climate change demand adaptive learning approaches that are relevant to today's challenges. ESD focuses not only on knowledge transfer, but also on developing students' critical competencies and concrete actions in support of sustainability (Shen et al., 2025). In the context of Animal Biosystematics, understanding of phylogeny and species adaptation can be enriched by field studies that explore the impact of human activities on ecosystems. Meanwhile, in terms of Evolution, outdoor learning allows students to see evidence of evolution first-hand, such as genetic variation between populations, which is relevant to conservation issues (Jekel Könnel et al., 2025).

Based on these findings, the development of ESD-based outdoor learning strategies in the Animal Biosystematics and Evolution course is important to improve students' understanding of conservation and SDGs. The approach used in ESD-based outdoor learning in this study was also inspired by the conceptual framework developed by El-Aasar (Firreno et al., 2023), which was adopted by UNESCO as a roadmap for ESD, and integrated with the Whole-Institution Approach and Anne Taylor's theory of the Learning Environment as a 3D Textbook (Figure 1).



**Figure 1.** (a) Whole-Institution Approach, (b) The Anne Taylor Framework for Learning Environment as a 3D-TextBook

As illustrated in Figure 1, this study integrates two complementary frameworks to operationalize ESD-based outdoor learning in the Animal Biosystematics and Evolution course. Figure 1(a), the Whole-Institution Approach (UNESCO, 2020), structures the learning environment across three interconnected levels that translate directly into concrete activities. At the formal curriculum level, structured outdoor field sessions are embedded in the course syllabus as compulsory learning activities. For example, guided species observation exercises in campus botanical gardens in which students apply taxonomic keys to classify local fauna and flora. At the informal curriculum level, students voluntarily participate in campus biodiversity documentation projects, photographing and recording species encountered in open spaces and contributing observations to shared databases. At the institutional culture level, ecological stewardship norms are modelled through course assessment criteria that reward honest data reporting and collaborative field ethics, embedding the values of scientific integrity into the hidden curriculum (Bürgener & Barth, 2022; El-Aasar et al., 2024).

The second framework guiding this study draws on Anne Taylor's notion that the built and natural environment surrounding a learning institution can function as a living, three-dimensional textbook a concept operationalised here through the physical layout of the university campus and its surrounding ecological spaces (Taylor, 1993, as cited in El-Aasar et al., 2024). In practice, this translated into three overlapping dimensions of learning experience that collectively redefined the educational role of the campus environment. Rather than serving merely as a backdrop for instructional activities, the campus and its surrounding ecological spaces became active pedagogical resources that shaped what students learned, how they learned, and where learning occurred. This perspective reflects Taylor's proposition that educational environments are not neutral settings but integral components of the learning process, capable of influencing students' cognitive, social, and environmental development.

The first is what students really learn. Instead of only handling pinned specimens in museum drawers or images in field guides, students were taken into campus gardens and a nearby zoo to learn taxonomic identification and trace phylogenetic relationships with organisms they could see moving, feeding and behaving. The encounter with living material transformed the nature of the task identification became something students did, not something they read about. The second aspect is the way in which that learning takes place. Passive note-taking was exchanged for collaborative fieldwork: students mapped species distributions, collaboratively recorded observations and returned to the classroom to analyse shared datasets as a group. This shift from receptive to generative learning reflects what ESD-oriented pedagogy demands of both students and instructors (Neville et al., 2023; Wu et al., 2024). The third dimension is perhaps the most straightforward yet the most overlooked in conventional biology instruction: *where* learning takes place matters. Conducting biosystematics work inside campus open spaces and local conservation areas meant that the connection between species classification and real conservation stakes particularly those tied to SDG 15 was not something students had to imagine. It was something they could see.

Together, these two frameworks ensure that the outdoor learning design is not merely spatially relocated instruction but a pedagogically purposeful transformation of the learning environment into a site of sustainability-oriented inquiry (El-Aasar et al., 2024; Wu et al., 2024). This approach not only

supports the achievement of academic competencies but also shapes agents of change who are aware of their ecological responsibilities in the future (Haaland & Baklien, 2024).

This study is expected to support previous research in order to realize the faculty's flagship research related to active learning that utilizes the environment. This research also aims to improve students' competence in analyzing biodiversity and evolution in a contextual manner, while providing practical benefit in the form of strengthening pro-conservation attitudes that support the SDGs. In addition, the results of this approach can contribute to educational institutions in producing graduates who are not only scientifically competent but also have ecological responsibility, thereby supporting sustainable development at both the local and global levels.

## 2. Method

This study employed a quasi-experimental one-group pretest-posttest design to examine the effect of ESD-based outdoor learning on students' conceptual understanding of animal biosystematics, evolutionary processes, and conservation. In this design, students' understanding was measured before (pretest) and after (posttest) the outdoor learning intervention, with the difference in scores used to assess the learning gains attributable to the treatment (Creswell & Creswell, 2023). The research hypothesis addressed in this study is: ESD-based outdoor learning significantly improves undergraduate students' conceptual understanding of biodiversity, evolutionary processes, and conservation principles in the Animal Biosystematics and Evolution course.

First, the research team also reviewed literature studies, including: various studies on SDGs; learning designs related to conservation in SDG programmes and Animal Biosystematics and Evolution courses; outdoor learning designs to be used in Animal Biosystematics and Evolution learning and materials related to SDG programmes in environmental conservation and learning frameworks related to sustainable quality education for instrument development. The findings in the field were analyzed to determine: how SDG programmes are linked to sustainable conservation in the Animal Biosystematics and Evolution course curriculum; how learning designs related to outdoor learning in the Animal Biosystematics and Evolution course can be implemented; and how data is collected and processed. The analysis also included a curriculum analysis of the study programme, particularly the Animal Biosystematics and Evolution course, which will be used in the research. The analysis phase is planned to be carried out over three months.

This research was conducted at Bandung City, Indonesia. Participants were 37 undergraduate Biology Education students (female: 22; male: 15; mean age: 19.4 years, SD = 0.6) enrolled in the Animal Biosystematics and Evolution course. Sampling was conducted using purposive sampling based on course enrolment, as all students were required to participate in the outdoor learning intervention as part of the regular course structure (Etikan et al., 2016). Inclusion criteria were: (1) actively enrolled in the course during the study period, and (2) completion of prerequisite courses in General Biology dan Animal Structure. Students who were absent for more than one outdoor session were excluded from the final analysis. Written informed consent was obtained from all participants prior to data collection, and ethical clearance was granted by the institutional research ethics committee.

The implementation stages focused on conducting research on outdoor learning with students as subjects. Data in the form of learning outcomes and student responses related to the implementation of outdoor learning were collected, processed, transformed and analyzed to reveal the effectiveness of the developed design system. This research also included a comprehensive evaluation of the impact of SDG-based outdoor learning on students' understanding of conservation and sustainability. The evaluation involves the collection of qualitative and quantitative data to provide a more comprehensive picture. Qualitative data is obtained through questionnaires/student responses to outdoor learning. Meanwhile, quantitative data is collected through pre-tests and post-tests to measure the increase in students' conceptual understanding of Animal Biosystematics material and conservation issues in the context of SDGs.

The research instruments used included 30-item multiple-choice written test covering three content domains: (1) animal taxonomy and biosystematics (10 items, Bloom's C1–C3); (2) evolutionary processes and phylogenetics (10 items, C2–C4); and (3) conservation principles and SDG-aligned biodiversity management (10 items, C3–C4). Content validity was assessed by two biology education experts and two subject-matter specialists using the Content Validity Ratio (CVR = 0.87; Lawshe, 1975), indicating acceptable item-level validity. Internal consistency reliability was strong (Cronbach's  $\alpha$  = 0.81), confirming adequate instrument reliability for measuring conceptual understanding (Creswell &

Creswell, 2023). The written tests were designed to measure students' cognitive abilities in understanding the concepts of biosystematics, evolution, and their relevance to the SDGs program.

The questionnaires aimed to gather feedback on the effectiveness of the instruction, the relevance of the material, and the overall learning experience. using a 4-point Likert scale (1 = Strongly Disagree, 4 = Strongly Agree) organized around the Who, What, Where, and How dimensions of El-Aasar et al.'s (2024) outdoor learning framework (five items per dimension), supplemented by two open-ended questions to explore students' in-depth impressions of the ESD-based outdoor learning experience. Questionnaire content validity was confirmed through expert review (CVR = 0.84), and reliability was high (Cronbach's  $\alpha = 0.872$ ), consistent with accepted standards for Likert-scale instruments in educational research (Maulana et al., 2022).

All statistical analyses in this study were performed using IBM SPSS Statistics 26. Before any inferential testing could be initiated, the data had to meet a rudimentary but indispensable prerequisite: demonstrating that the scores were distributed sufficiently normally to permit the application of parametric methods. Given that the sample in this study consisted of 37 participants well below the  $n = 50$  threshold commonly used to distinguish small from moderate samples the Shapiro–Wilk test was the appropriate choice for this purpose. The advantage of this test over the more commonly used Kolmogorov–Smirnov test has been well documented. The Shapiro–Wilk test is consistently more sensitive to departures from normality for smaller data sets, and thus is the more reliable choice in this context (Razali & Wah, 2011; Mishra et al., 2019). The Shapiro–Wilk test was applied to the pretest–posttest difference scores the variable directly relevant to the paired t-test assumption rather than to raw scores independently, as recommended by standard parametric testing protocols (Freidlin et al., 2003). Results confirmed that the difference scores were normally distributed ( $W = 0.963$ ,  $p = .236$ ), satisfying the parametric assumption for the paired sample t-test. The assumption of no significant outliers was additionally verified through visual inspection of boxplots.

Second, a paired sample t-test ( $\alpha = .05$ , two-tailed) was conducted to determine the statistical significance of the improvement in students' conceptual understanding following the ESD-based outdoor learning intervention. The paired t-test was selected because the same group of students was measured twice (pretest and posttest) under non-independent conditions, making it the appropriate test for within-subject repeated measures designs (Creswell & Creswell, 2023). Third, to assess practical significance beyond statistical significance, effect size was calculated using both Cohen's  $d$  and Hedges'  $g$ . Hedges'  $g$  was included as an additional measure because it applies a correction factor for small sample sizes ( $n = 37$ ), reducing the upward bias inherent in Cohen's  $d$  when samples are small (Lakens, 2013). Fourth, qualitative data from the open-ended questionnaire items were analyzed thematically following Braun and Clarke's (2006) reflexive thematic analysis framework to identify patterns in students' perceptions of the ESD-based outdoor learning experience. Fifth, instrument reliability was confirmed using Cronbach's Alpha ( $\alpha = 0.872$  for the questionnaire;  $\alpha = 0.81$  for the written test), consistent with the threshold of  $\alpha \geq 0.70$  recommended for research instruments in educational studies (Maulana et al., 2022).

Data on students' perceptions and responses to ESD-based outdoor learning was collected using a 1-4 Likert scale questionnaire and two open-ended questions to explore their in-depth impressions of outdoor learning designed based on the conceptual framework of El-Aasar et al. (2024). This questionnaire was developed with reference to UNESCO's whole-institution approach and Anne Taylor's '3D Textbook' learning environment theory, which views the learning environment as an integral part of the active and continuous learning process. The questionnaire consisted of 10 questions covering four main dimensions, namely who is involved (Who), what is learned (What), where learning takes place (Where), and how the learning process takes place (How), as well as two open-ended questions to explore students' in-depth impressions of ESD-based outdoor learning.

The four dimensions of the questionnaire Who, What, Where and How are not arbitrary but correspond instead to the foundation pillars of learning. These pillars have long been recognized in the ESD scholarship as fundamental to meaningful sustainability education. To confirm that the instrument was measuring what it was supposed to measure, the questionnaire was content reviewed by specialists in both biology education and conservation, and the feedback was incorporated into the revision of the instrument before it was finalized. Reliability was then assessed using Cronbach's Alpha. The resulting coefficient for  $\alpha = 0.872$  is well above the threshold generally considered acceptable in educational research, giving reasonable confidence that the questionnaire items were measuring an underlying construct coherently and consistently across respondents.

But the numbers only hint at the value of this study. The findings provide at a practical level a concrete reference point for educators and curriculum designers in their efforts to take ESD from a

policy commitment on paper to something that actually shapes how biology is taught and experienced. The outdoor learning model developed here, based on real ecological fieldwork and organized around SDG-relevant content, could be a workable template for other courses grappling with similar goals. Beyond the classroom, the study is relevant to a wider set of stakeholders: those charged with institutional curriculum policy who require evidence that alternative pedagogical approaches can meet critical global issues, from biodiversity loss and species extinction to climate change and social inequity, without compromising academic rigor. Most importantly, the study challenges the tendency to consider theory and practice in biology education as separate domains. What students learn about conservation needs to connect to how they are taught to think about conservation and where that thinking takes place.

### 3. Results and Discussion

The effectiveness of implementation of outdoor learning based on Education for Sustainable Development (ESD) was analyzed by assessing the students' cognitive abilities before and after the treatment by using pre-tests and post-tests. Quantitative data was collected from 37 students who enrolled in the Animal Biosystematics course. Descriptive statistics for students' pre-test and post-test scores are presented in Table 1.

**Table 1.** Descriptive Statistics of Students' Pre-test and Post-test Scores

| <b>Statistic</b>   | <b>Pretest</b> | <b>Posttest</b> | <b>Gain</b> |
|--------------------|----------------|-----------------|-------------|
| N                  | 37             | 37              | 37          |
| Average            | 81,29          | 90,24           | 8,95        |
| Standard Deviation | 3,65           | 4,98            | 2,14        |
| Minimum Score      | 74             | 83              | 6           |
| Maximum Score      | 85             | 95              | 12          |

Based on Table 1, the analysis results show that there is a significant difference between the pretest and posttest scores of the students. The posttest mean score ( $M = 90.24$ ,  $SD = 4.98$ ) is significantly higher than the pretest score ( $M = 81.29$ ,  $SD = 3.65$ ), with  $p < 0.05$ . This improvement reflects a significant difference in conceptual understanding after outdoor learning was implemented. The minimum pretest score was 74 and the maximum was 85, while the posttest scores ranged from 83 to 95. The improvement in individual scores was calculated as a gain value showing an average increase of 8.95, with a range of increase between 6 and 12 points.

To determine the significance of the increase in students' understanding after participating in ESD-based outdoor learning, a statistical analysis using a paired sample t-test was conducted on the pretest and posttest data, as shown in Table 2.

**Table 2.** Paired Sample t-Test

|                 |          |
|-----------------|----------|
| Mean            | -8.94595 |
| Std. Deviation  | 2.17238  |
| Std. Error Mean | .35714   |
| t-value         | -25.049  |
| df              | 36       |
| One-Sided p     | <.001    |
| Two-Sided p     | <.001    |

The test results in Table 2 showed a t-value of -25.049, with  $df = 36$  and a two-tailed significance value ( $p < 0.001$ ). This indicates that there is a very significant difference between the pre- and post-treatment scores. In addition, the correlation between the pre-test and post-test scores was  $r = 0.918$ , indicating a very strong relationship between the two variables. To determine the strength of the influence of ESD-based outdoor learning on students' conceptual understanding of conservation, an effect size analysis was conducted, where Cohen's  $d$  value was 2.172 and Hedges'  $g$  was 2.219, as shown in Table 3.

Table 3. Paired Samples Effect Sizes

|        |                    |                    | 95% Confidence Interval   |                |        |        |
|--------|--------------------|--------------------|---------------------------|----------------|--------|--------|
|        |                    |                    | Standardizer <sup>a</sup> | Point Estimate | Lower  | Upper  |
| Pair 1 | Pretest - Posttest | Cohen's <i>d</i>   | 2.17238                   | -4.118         | -5.115 | -3.114 |
|        |                    | Hedges' correction | 2.21898                   | -4.032         | -5.007 | -3.048 |

A Cohen's *d* score exceeding 2.0 ( $d = 2.17$ ) classifies this as a very large effect size according to Cohen's (1988) benchmarks (small:  $d > 0.2$ ; medium:  $d > 0.5$ ; large:  $d > 0.8$ ). A Cohen's *d* of 2.17 is, by any conventional standard, a striking number. Yet striking numbers in educational research have a way of demanding scrutiny rather than celebration, and this one is no exception. Magnitude alone is not enough to answer the question of whether the intervention actually drives the observed improvement; It just tells us that pre- and post-test scores are very different relative to their variability.

Some features of the study design are known to push effect size estimation upwards, sometimes substantially. Kraft (2020) and Lortie-Forgues and Inglis (2019) both noted that educational studies that combined small groups of participants, outcome measures built specifically around the interventions being tested, and the absence of comparison groups tended to produce effect measures that seemed impressive on paper but exaggerated what would be found under more controlled conditions. The study met all three criteria: 37 participants, a test developed by the research team to precisely assess the content taught during outdoor sessions, and one group measured before and after without any comparison groups criteria: 37 participants, a test developed by the research team to precisely assess the content taught during the outdoor session, and one group measured before and after without any comparison groups. Combined, these conditions mean that  $d = 2.17$  is more accurately read as an upper limit estimate of what the effect might be, rather than an exact or conservative estimate (Lortie-Forgues & Inglis, 2019; Cheung & Slavin, 2016).

The design of this study presents additional uncertainties that cannot be ignored. When the same group of students take the preliminary test at the beginning of the semester and the final test at the end of the semester, a number of factors can explain the difference between the two scores in addition to the outdoor learning session itself. Students develop intellectually over the course of a semester. They take other classes, read for other purposes, and gather experiences related to biology and conservation in ways that researchers cannot track or control. They also grow familiar with the format and style of the test items, which may improve performance independently of any genuine conceptual growth. None of these alternative explanations can be ruled out when there is no control group against which to benchmark the treated group's trajectory. What the data show is real improvement the gain score of  $M = 8.95$  and the remarkably high pre-post correlation of  $r = 0.918$  both point in the same direction. What they cannot show, on their own, is that the outdoor learning intervention was the reason for it. These alternative explanations cannot be ruled out without a randomised control group (Creswell & Creswell, 2023).

Nonetheless, several converging indicators provide conditional support for attributing the improvement to the ESD-based outdoor learning intervention: the large absolute gain score ( $M = 8.95$  points), the near-perfect pre-post correlation ( $r = 0.918$ ) indicating consistent individual improvement across the sample, and the theoretical coherence of the finding with established evidence that contextual, environment-based learning enhances concept retention and ecological understanding in biology students (Könnel et al., 2025; Mann et al., 2023; Wu et al., 2024). These findings identify that ESD-based outdoor learning produced a meaningful and practically significant improvement in students' understanding, while future studies with randomised controlled designs and larger samples are needed to establish stronger causal claims.

This identifies that the difference between the pretest and posttest scores is not only statistically significant but also practically meaningful. The improvement recorded in this study did not emerge from random fluctuation in scores the statistical pattern is consistent enough to suggest that something about the learning experience itself drove the change. This interpretation is in line with a number of studies

showing that when students learn science through direct engagement with the real environment rather than its abstract representations, both their motivation to engage and their ability to remember what they have learned tend to increase significantly. The contribution of the ESD framework here goes beyond just pedagogical labels. Basing the teaching of biosystems on questions about the survival of local species, habitat loss, and ecosystem function gives students a reason to care about taxonomy that a list of classification criteria cannot provide. These concepts cease to be knowledge that must be memorized and become tools for understanding something that students can see and touch. This shift from knowing about conservation to thinking about it directly is what sustainability-oriented education is designed to produce, and it echoes what scholars have long argued about the inadequacy of treating science content separately from its social and ecological stakes (UNESCO, 2017).

There is also something to be concerned about what happens on campus or field location when intentionally integrated into a course rather than just being treated as a background. The open space that students pass through during this study is not just a place, but part of the curriculum itself. Species found in campus gardens become data. A visit to the zoo is not just enrichment, but field work. The reframing of the environment as pedagogy, not just as a setting, reflects a broader principle: that the transformation of how and where learning occurs can change what students are able to understand, not just what they experience (Chineme et al., 2019). Integrating SDG-relevant challenges directly into the structure of biosystems courses is one concrete way to realize these principles.

The questionnaire results from 37 students showed that, in general, perceptions of the implementation of outdoor learning based on Education for Sustainable Development (ESD) were very positive. Most students responded with Strongly Agree (SA) and Agree (A) categories to all statements, with an average of 91.6%. The analysis of the questionnaire results was based on four main dimensions in line with the whole-institute ESD approach framework, namely who is involved (Who), what is being learned (What), where the learning takes place (Where), and how the learning process is carried out (How). Table 4 presents the percentage of students responding with Strongly Agree (SA) and Agree (A) for each item across the four dimensions of the El-Aasar et al. (2024) framework. The overall mean agreement rate was 91.6%, indicating highly positive perceptions across all dimensions. Table 4 presents the percentage of students responding with Strongly Agree (SA) and Agree (A) for each item across the four dimensions of the El-Aasar et al. (2024) framework. The overall mean agreement rate was 91.6%, indicating highly positive perceptions across all dimensions. Summary of student questionnaire responses by dimension are presented in Table 4.

**Table 4.** Summary of Student Questionnaire Responses by Dimension (N = 37)

| <i>Dimension</i>                    | <i>SA+A (%)</i> | <i>Category</i> |
|-------------------------------------|-----------------|-----------------|
| Who (Participation & Collaboration) | 93.0            | Very Positive   |
| What (Learning Content)             | 91.4            | Very Positive   |
| How (Learning Process)              | 90.8            | Very Positive   |
| Where (Learning Environment)        | 88.6            | Positive        |
| Overall Mean                        | 91.6            | Very Positive   |

Note: SA = Strongly Agree; A = Agree. Category: Very Positive (>90%), Positive (75–90%).

The Where dimension showed the lowest mean agreement (88.6%), driven primarily by the item regarding campus facility adequacy for ESD activities (67.6% SA+A), which aligns with the finding that 68% of students perceived current campus infrastructure as not fully supporting ESD-based learning. This is consistent with Eriksson et al. (2023), who identified facility availability as a critical enabler of outdoor science learning in higher education. Conversely, the Who dimension obtained the highest agreement (93.0%), indicating that students strongly valued the collaborative and participatory dimensions of outdoor learning a finding consistent with Mann et al. (2023), who demonstrated that perceived peer collaboration is among the strongest predictors of student engagement in outdoor learning programmes.

A total of 92% of respondents in the Who dimension agreed or strongly agreed that the involvement of various parties (students with students, lecturers with students) is very important for developing learning that is relevant to sustainability issues. They also believe that they must be directly involved in

the planning and implementation of outdoor learning. These findings confirm that students must be actively involved in change in the context of sustainable education. This is in line with UNESCO's (2020) view that a comprehensive institutional approach is needed to implement ESD.

Environments that implement group collaboration, such as outdoor learning, significantly improve students' understanding of learning objectives and social relationships between students. This applies to both face-to-face learning, which demonstrates the effectiveness of group collaboration learning methods in various situations (Sovic). Outdoor learning is one of the main components of ESD. Programmes such as lifelong learning through nature show that outdoor learning can significantly improve students' knowledge and attitudes towards nature, highlighting the importance of teamwork in this learning process (Ghadiri et al., 2018; Kusumadani et al., 2025). Group collaboration learning facilitates interdisciplinary learning, integrating various subjects such as science, humanities, and outdoor learning. This approach helps students understand the interrelationships between various sustainability issues and develop comprehensive solutions (Dettweiler et al., 2017). In addition, effective ESD implementation requires collaboration between teachers and students. Teachers need to be smart in adapting their approach to the curriculum, making subjects like geography engaging and challenging, which increases student engagement and learning (Neville et al., 2023).

In terms of "What", the survey results showed that students were able to relate the subject matter to the Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education) and SDG 15 (Life on Land). Approximately 88% of students who responded said that the material taught outside the classroom had improved their understanding of these concepts. This supports the statement (El-Aasar et al., 2024) that adding ESD principles to the curriculum can increase learners' awareness of international issues and encourage them to participate in contextual local actions. Furthermore, this is in line with outdoor learning improving academic learning, social competence, personal and emotional development, psychological well-being, and physical health. It fosters environmental awareness and helps learners face sustainability challenges, contributing to the implementation of SDG 4 (Eriksson et al., 2023).

Outdoor learning programmes often focus on local species and habitats, encouraging a deeper understanding of biodiversity and conservation efforts. For example, students involved in conservation through outdoor learning activities contribute to species protection and habitat restoration (Neville et al., 2023). Outdoor education increases students' awareness and knowledge of local biodiversity, and encourages positive attitudes and behaviours towards the environment. (Wuzhuoma & Aziz, 2025) Outdoor learning significantly supports the understanding and implementation of SDG 4 and SDG 15 by increasing environmental awareness, promoting lifelong learning, and improving knowledge about local species conservation. Through experiential and participatory approaches, outdoor education can effectively contribute to achieving sustainability goals. Outdoor learning offers valuable and diverse learning experiences that enhance engagement, holistic development, and social connections. However, successful implementation requires addressing challenges such as learning continuity and lecturer readiness.

Based on the Where dimension analysis, 97% of student responses considered outdoor environments, such as campus gardens and open spaces, to provide a significant learning experience. However, as many as 68% of students felt that current campus facilities did not fully support ESD-based learning. Therefore, in this study, students could be taken to places that would enable them to learn concepts in the Animal Biosystematics course, such as the nearest zoo. Taylor (Furman et al., 2019), through the concept of learning environment as a 3D textbook, emphasises the importance of creating a physical learning environment that encourages active, exploratory, and reflective learning processes.

Outdoor environments encourage authentic science learning by allowing students to interact with diverse ecosystems and participate in data collection practices, which are difficult to replicate in indoor environments (Dwi Hastika & Supriatno, 2024). These environments support experiential learning, which can increase students' intrinsic motivation and knowledge acquisition (Saefudin, Kusnadi, Hastika, et al., 2025). In addition, learning in natural environments builds social and ecological connections through active engagement, sensory experiences, and responsibility (Saefudin, Kusnadi, Suwandi, et al., 2025).

Meanwhile, in terms of How, most students (95%) stated that hands-on methods outside the classroom, such as field exploration, species observation, and open discussions, greatly helped them understand the material more deeply. Outdoor learning facilitates a holistic, meaningful, and empirical understanding of science concepts and encourages students to solve real-world problems (Fadila &

Hariyati, 2022). In line with this, the study explains that the use of concrete media and direct interaction with the environment can strengthen theoretical understanding and build students' practical and emotional capacities. In fact, the majority stated that this method was more enjoyable than conventional classroom learning. This demonstrates the effectiveness of the active learning approach in ESD-based biology learning, as stated by Macalalag et al (2024) that outdoor learning can significantly increase students' emotional engagement and concept retention. Emotional engagement makes students feel that they are part of the solution to environmental problems.

Learning activities that involve hands-on practice or outdoor exploration can significantly improve students' understanding and retention of material. Outdoor learning allows students to apply theoretical knowledge to real-world situations, which helps them retain information better and consolidate concepts into long-term memory (Kioupi & Voulvoulis, 2019). Outdoor learning activities can complement indoor teaching by explaining abstract theoretical points and expanding content knowledge. Outdoor learning is highly motivating for students, helping them to delve deeper into the material and fostering a sense of connection with nature (Beauchamp et al., 2022).

In addition, when asked about their involvement in future learning, more than 67% of students expressed their willingness to participate in the planning or implementation of the next outdoor learning activity. This reflects the enthusiasm and concern of students for the continuity of learning that is relevant to the surrounding environment. Students are not only passive participants, but also show potential to be active contributors in the ESD-based learning process. These results are in line with the idea of student agency in sustainability education, which emphasises the importance of students actively participating in learning decision-making and taking concrete action on environmental issues (Muñoz-Galván & Padilla, 2024). Furthermore, this involvement shows that outdoor learning education has the ability to provide opportunities for students to engage with real-world contexts, thereby supporting a transformative approach in ESD (O'Grady, 2023).

Outdoor learning is an additional approach that can be easily integrated into regular education at low cost, making it a valuable tool for future education systems (White et al., 2018). It supports academic learning, social interaction, personal development, well-being, and creativity (Prince, 2019). Outdoor learning supports academic development, social competence, personal and emotional growth, psychological wellbeing, and physical health (Edwards-Jones et al., 2018).

In the open-ended question about the most memorable aspect of the outdoor learning experience, most students stated that this activity encouraged them to think more critically about sustainability and conservation issues. They felt compelled to reflect on the impact of human activities on the environment and realised the importance of young people's involvement in preserving the ecosystem. This shows that outdoor learning not only improves cognitive understanding, but also shapes ecological awareness and environmental empathy. Hands-on experience in the field strengthens the link between theory and practice, and fosters an affective dimension that is important in sustainability-based education (Awaluddin et al., 2021), including ecological empathy, which is an important foundation in sustainability-based education.

#### 4. Conclusion

This study demonstrates that ESD-based outdoor learning significantly improves undergraduate students' conceptual understanding of biodiversity, evolutionary processes, and conservation in the Animal Biosystematics and Evolution course ( $t(36) = -25.049$ ,  $p < .001$ ,  $d = 2.17$ ). To the authors' knowledge, this particular framework integration has not been previously reported in the ESD or biology education literature, positioning this study as an original contribution to contextual science pedagogy aligned with SDG 4 and SDG 15. Beyond the cognitive gains, student questionnaire responses confirmed high agreement across all four framework dimensions (overall SA+A = 91.6%), with the Who dimension reflecting collaborative and participatory engagement obtaining the highest response (93.0%). More than 67% of students expressed willingness to participate in future ESD-based activities, indicating that the intervention generated durable motivational impact alongside the measured conceptual improvements.

Future research should address the methodological limitations of this study particularly the single-group design and small sample by employing randomised controlled designs with larger, multi-institutional samples to establish stronger causal claims. Longitudinal studies examining the persistence of conservation attitudes and behaviours beyond the course, as well as comparative studies across

different biological field sites and course contexts, would further strengthen the evidence base for ESD-based outdoor learning in higher biology education.

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### References

- Abi, M., Hidayat, R., Wulandari, H., & Negara, H. S. (2022). Implementasi Model Outdoor Learning terhadap Kemampuan Pemahaman Konsep IPA. *JIIP: Jurnal Ilmiah Ilmu Pendidikan*, 5(8). <http://Jiip.stkipyapisdompmpu.ac.id>
- Anggoro, I., Suhendro, P. P. M., Fahrurrozi, F., & Hasanah, U. (2024). Analisis Gaya Belajar Siswa dalam Mengoptimalkan Pemahaman Siswa: Studi Deskriptif di SD Negeri Klender 10. *Ideguru: Jurnal Karya Ilmiah Guru*, 9(3), 1686–1692. <https://doi.org/10.51169/ideguru.v9i3.1067>
- Awaluddin, R., Setiyadi, W., & Dompmpu, A. (2021). Pengaruh Metode Pembelajaran Outdoor Learning Berbentuk Jelajah Lingkungan Terhadap Motivasi dan Hasil Belajar Siswa. *Jurnal Pendidikan Biologi*, 10(2), 45–53.
- Barrable, D., & Barrable, A. (2024). Affordances of coastal environments to support teaching and learning: outdoor learning at the beach in Scotland. *Education 3-13*, 52(3), 416–427. <https://doi.org/10.1080/03004279.2022.2100440>
- Beauchamp, A. A., Lacoste, Y., Kingsbury, C., & Gadais, T. (2022). When are you taking us outside? An exploratory study of the integration of the outdoor learning in preschool and primary education in Quebec. *Frontiers in Psychology*, 13. <https://doi.org/10.3389/fpsyg.2022.955549>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Bürgener, L., & Barth, M. (2018). Sustainability competencies in teacher education: Making teacher education count in everyday school practice. *Journal of Cleaner Production*, 174(October), 821–826. <https://doi.org/10.1016/j.jclepro.2017.10.263>
- Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.
- Capkinoglu, E., Yilmaz, S., & Leblebicioglu, G. (2020). Quality of argumentation by seventh-graders in local socioscientific issues. *Journal of Research in Science Teaching*, 57(6), 827–855. <https://doi.org/10.1002/tea.21609>
- Cheung, A. C. K., & Slavin, R. E. (2016). How methodological features affect effect sizes in education. *Educational Researcher*, 45(5), 283–292. <https://doi.org/10.3102/0013189X16656615>
- Chineme, A., Herremans, I., & Wills, S. (2019). Building Leadership Competencies for the SDGs through Community/University Experiential Learning. *Journal of Sustainability Research*, 1(2). <https://doi.org/10.20900/jsr20190018>
- Dettweiler, U., Lauterbach, G., Becker, C., & Simon, P. (2017). A bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Frontiers in Psychology*, 8(DEC). <https://doi.org/10.3389/fpsyg.2017.02235>
- Dwi Hastika, A., & Supriatno, B. (2024). Developing Sustainability Competencies: Critical and Anticipatory Thinking through Botanical Eco-Gamification Program. *EASE Letters*, 3(2), 2951–6420.
- Edwards-Jones, A., Waite, S., & Passy, R. (2018). Falling into LINE: school strategies for overcoming challenges associated with learning in natural environments (LINE). *Education 3-13*, 46(1), 49–63. <https://doi.org/10.1080/03004279.2016.1176066>
- El-Aasar, M., Shafik, Z., & Abou-Bakr, D. (2024). Outdoor learning environment as a teaching tool for

- integrating education for sustainable development in kindergarten, Egypt. *Ain Shams Engineering Journal*, 15(4). <https://doi.org/10.1016/j.asej.2024.102629>
- Eriksson, M., Kärkkäinen, S., & Tahvanainen, V. (2023). Technology-mediated outdoor learning for primary school student teachers: Focusing on biodiversity. *Journal of Computer Assisted Learning*, 39(6), 1819–1833. <https://doi.org/10.1111/jcal.12841>
- Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical and Applied Statistics*, 5(1), 1–4. <https://doi.org/10.11648/j.ajtas.20160501.11>
- Fadila, N., & Hariyati, N. (2022). Implementasi Pembelajaran Luar Kelas (Outdoor Learning) di Sekolah Kreatif SD Muhammadiyah 16 Surabaya. *Jurnal Pendidikan Dasar*, 10(1), 112–121.
- Fajri, Citrawathi, Adnyana, Arnyana, Sarnita, & Fitriani. (2025). The strategic role of conservation education in efforts to improve biodiversity literacy. <https://doi.org/10.36681/tused.2025.019>
- Furman, M., Luzuriaga, M., Taylor, I., Jarvis, D., Dominguez Prost, E., & Podestá, M. E. (2019). The use of questions in early years science: a case study in Argentine preschools. *International Journal of Early Years Education*, 27(3), 271–286. <https://doi.org/10.1080/09669760.2018.1506319>
- Ghadiri Khanaposhtani, M., Liu, C. C. J., Gottesman, B. L., Shepardson, D., & Pijanowski, B. (2018). Evidence that an informal environmental summer camp can contribute to the construction of the conceptual understanding and situational interest of STEM in middle-school youth. *International Journal of Science Education, Part B: Communication and Public Engagement*, 8(3), 227–249. <https://doi.org/10.1080/21548455.2018.1451665>
- Haaland, J. J., & Baklien, B. (2024). Friluftsliv in residential youth care: a resilience perspective on character-forming outdoor experiences. *Journal of Adventure Education and Outdoor Learning*. <https://doi.org/10.1080/14729679.2024.2344031>
- J., Welsh, G. T., Nimlos, P. J., & Larson, E. L. (2023). “I think”: integrating project-based learning and case study to teach fundamentals of evolutionary tree-thinking. *Evolution: Education and Outreach*, 16(1). <https://doi.org/10.1186/s12052-023-00192-8>
- Jekel Könnel, E., Geuer, L., Schlindwein, A., Perret, S., & Ulber, R. (2025). The Effects of an Outdoor Learning Program, ‘GewässerCampus’, in the Context of Environmental Education. *Education Sciences*, 15(5). <https://doi.org/10.3390/educsci15050550>
- Jekel Könnel, E., Geuer, L., Schlindwein, A., Perret, S., & Ulber, R. (2025b) — [DUPLICATE REMOVED]
- Kelly, O., Buckley, K., Lieberman, L. J., & Arndt, K. (2022). Universal Design for Learning - A framework for inclusion in Outdoor Learning. *Journal of Outdoor and Environmental Education*, 25(1), 75–89. <https://doi.org/10.1007/s42322-022-00096-z>
- Kioupi, V., & Voulvoulis, N. (2019). Education for sustainable development: A systemic framework for connecting the SDGs to educational outcomes. *Sustainability (Switzerland)*, 11(21). <https://doi.org/10.3390/su11216104>
- Könnel, E. J., Geuer, L., Schlindwein, A., Perret, S., & Ulber, R. (2025). The effects of an outdoor learning program, 'GewässerCampus', in the context of environmental education. *Education Sciences*, 15(5), 550. <https://doi.org/10.3390/educsci15050550>
- Kraft, M. A. (2020). Interpreting effect sizes of education interventions. *Educational Researcher*, 49(4), 241–253. <https://doi.org/10.3102/0013189X20912798>
- Kusumadani, A. I., Nabila, A. F., & Najwa, N. (2025). Comparison of the Learning Outcomes in the Ecology Course Using Socio-Scientific Problem based Learning and Stimulus Environment Problem Solving Models. *Journal of Biology Learning*, 7(1), 24-30. <https://doi.org/10.32585/jbl.v7i1.6435>
- Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: A practical primer for t-tests and ANOVAs. *Frontiers in Psychology*, 4, 863. <https://doi.org/10.3389/fpsyg.2013.00863>
- Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology*, 28(4), 563–575.
- Lortie-Forgues, H., & Inglis, M. (2019). Rigorous large-scale educational RCTs are often uninformative: Should we be concerned? *Educational Researcher*, 48(3), 158–166. <https://doi.org/10.3102/0013189X19832850>
- Macalalag, A. Z., Kaufmann, A., Van Meter, B., Ricketts, A., Liao, E., & Ialacci, G. (2024). Socioscientific

- issues: promoting science teachers' pedagogy on social justice. *Disciplinary and Interdisciplinary Science Education Research*, 6(1). <https://doi.org/10.1186/s43031-024-00118-4>
- Mann, J., Gray, T., & Truong, S. (2023). Does growth in the outdoors stay in the outdoors? *Frontiers in Psychology*, 14, 1102610. <https://doi.org/10.3389/fpsyg.2023.1102610>
- Maulana, R., Helms-Lorenz, M., Irnidayanti, Y., D400, S., & van de Grift, W. (2022). Motivation to learn science: Measurement and validation in Indonesian secondary schools. *International Journal of Science Education*, 44(9), 1456–1478. <https://doi.org/10.1080/09500693.2022.2075358>
- Mishra, P., et al. (2019). Descriptive statistics and normality tests for statistical data. *Annals of Cardiac Anaesthesia*, 22(1), 67–72. [https://doi.org/10.4103/aca.ACA\\_157\\_18](https://doi.org/10.4103/aca.ACA_157_18)
- Muñoz-Galván, M., & Padilla, K. (2024). Pedagogical content knowledge about the sustainability of high school chemistry and biology teachers. *Journal of Environmental Studies and Sciences*. <https://doi.org/10.1007/s13412-024-00919-z>
- Neville, I. A., Petrass, L. A., & Ben, F. (2023). Cross disciplinary teaching: A pedagogical model to support teachers in the development and implementation of outdoor learning opportunities. *Journal of Outdoor and Environmental Education*, 26(1), 1–21. <https://doi.org/10.1007/s42322-022-00109-x>
- O'Grady, M. (2023). Transformative education for sustainable development: A faculty perspective. *Environment, Development and Sustainability*. <https://doi.org/10.1007/s10668-023-03609-y>
- Pangsuma et al. (2024). Analysis of students' environmental literacy profile on behavioral components in Conservation Biology lectures. *Proceedings International Conference on Education, Science, Technology and Health (ICONESTH)*. 620-633 <https://doi.org/10.46244/iconesth.vi.368>
- Prince, H. E. (2019). Changes in outdoor learning in primary schools in England, 1995 and 2017: lessons for good practice. *Journal of Adventure Education and Outdoor Learning*, 19(4), 329–342. <https://doi.org/10.1080/14729679.2018.1548363>
- Purnama, D. (2024). Biodiversity decline and conservation challenges in Indonesia. *EDUCO: Environment Education and Conservation*, 1(2), 1–11. <https://doi.org/10.36868/EDUCO>
- Saefudin, Kusnadi, Suwandi, T., Najira, Baharudin, R., & Rachman, H. T. (2025). Integration Of Permaculture To Reinvent Students' Interest In Nature And Environmental Awareness For Quality Education Under Sdg-4. *Jurnal Pendidikan IPA Indonesia*, 14(1), 192–201. <https://doi.org/10.15294/jpii.v14i1.22122>
- Saefudin, S., Kusnadi, K., Hastika, A. D., & Zidan, Z. (2025). Development of a Gamification-Based Program to Support ESD Competency Improvement in Botanical Gardens. *JURNAL BIOEDUKATIKA*, 12(3), 17–28. <https://doi.org/10.26555/bioedukatika.v12i3.27922>
- Shen, Y. M., Sulaiman, M., Chen, G. L., Weng, H. C., Huang, C. M., Jamaludin, N. S., & Kadir, M. F. Z. (2025). Integrating biodiverse edible school practices: enriching undergraduate liberal education for elevated learning outcomes. *Frontiers in Education*, 10. <https://doi.org/10.3389/feduc.2025.1472179>
- White, R. L., Eberstein, K., & Scott, D. M. (2018). Birds in the playground: Evaluating the effectiveness of an urban environmental education project in enhancing school children's awareness, knowledge and attitudes towards local wildlife. *PLoS ONE*, 13(3). <https://doi.org/10.1371/journal.pone.0193993>
- Wu, S., et al. (2024). Outdoor education for sustainable development: A systematic literature review. *Sustainability*, 16(22), 10034. <https://doi.org/10.3390/su16221003>
- Wuzhuoma, L., & Aziz, S. (2025). Integrating Local Conservation Efforts with SDG15 in the Aba Prefecture China. *Journal of Environmental and Earth Sciences*, 7(2), 138–150. <https://doi.org/10.30564/jees.v7i2.7657>