



Bridging the Gap Between Lab and Life: Exploring Student Perceptions of Community-Based Citizen Science in Bio-Conservation Education

Siti Nurzainani Ulfa^{1*}, Diana Putri Prahasti², Fachri Aldin³

¹Universitas Islam Negeri Kiai Haji Ahmad Siddiq Jember, Indonesia

²Universitas Nurul Jadid, Indonesia

³NFU - National Formosa University, Taiwan

Article History:

Received: 02 December 2025

Revised: 14 February 2026

Accepted: 10 March 2026

Keywords:

Citizen Science, Student Perception, Environmental Education, Experiential Learning

*Correspondence Address:

zainaniulfa@ac.id

Abstract :

This study aims to explore students' perceptions of community-based citizen science in bio-conservation education and how such experiences bridge the gap between theoretical learning and real-life environmental engagement. A qualitative ethnographic approach was employed to capture students' lived experiences through participant observation, in-depth interviews, and document analysis. The findings reveal that participation in citizen science enhances students' conceptual understanding, environmental awareness, and sense of responsibility toward conservation. Students perceive these activities as meaningful when they are able to connect classroom knowledge with authentic field experiences. However, variations in engagement were observed, indicating that the effectiveness of citizen science depends on its implementation and relevance to students' learning contexts. The study implies that integrating community-based and experiential learning approaches into science education can foster deeper engagement and promote environmentally responsible behavior. It highlights the importance of designing student-centered and contextually relevant learning environments that emphasize collaboration, real-world application, and reflective practice.

INTRODUCTION

The growing environmental crisis, including biodiversity loss and ecosystem degradation, has intensified the need for more inclusive and participatory approaches to science education (MacPhail & Colla, 2020; Yan et al., 2023). Citizen science has emerged as a promising strategy to bridge the gap between scientific research and public engagement, particularly in fostering environmental awareness and stewardship among students. By involving learners directly in real-world scientific activities, citizen science promotes active learning and connects theoretical knowledge with practical application. This approach is increasingly recognized as essential for developing environmentally responsible citizens who can contribute to sustainable solutions. Empirical studies have demonstrated that participation in citizen science enhances students' environmental literacy, scientific understanding, and engagement with conservation issues. Therefore, integrating citizen science into education is not

only pedagogically beneficial but also socially relevant in addressing global environmental challenges. This study is important because it explores how students perceive these experiences, providing insights into how education can better connect laboratory learning with real-life environmental contexts (Ballard et al., 2024; Fraisl et al., 2022; Kelly et al., 2020).

Despite its potential, a significant problem remains in aligning formal science education with real-world environmental practices. Traditional biology education often emphasizes theoretical knowledge delivered in classroom or laboratory settings, which can limit students' ability to relate scientific concepts to real-life contexts. This disconnect may result in low engagement, reduced motivation, and limited understanding of the relevance of science to everyday life. Furthermore, students may struggle to see themselves as active contributors to scientific and environmental solutions. Research has highlighted that without meaningful engagement, students are less likely to develop long-term interest in conservation or scientific careers. Additionally, institutional and curricular constraints often hinder the integration of experiential and community-based learning approaches. As a result, there is a growing need to explore innovative educational models that can effectively bridge this gap and enhance student engagement and perception of science (Gormally & Heil, 2022; Fantinelli et al., 2024; Vance-Chalcraft et al., 2022).

In practice, various citizen science initiatives have been implemented in educational contexts, offering students opportunities to engage in authentic scientific activities such as biodiversity monitoring, environmental data collection, and conservation projects. These initiatives often involve collaboration between schools, communities, and researchers, creating dynamic learning environments that extend beyond the classroom. For example, school-based citizen science projects have shown positive impacts on students' environmental awareness, sense of responsibility, and scientific identity. However, observations also indicate that student engagement and perception vary depending on the design and implementation of these programs. Some students view these activities as meaningful and empowering, while others perceive them as additional tasks disconnected from their academic goals. These mixed experiences highlight the complexity of integrating citizen science into formal education and underscore the importance of understanding students' perspectives in shaping effective learning experiences (Williams et al., 2021; Wu & Hsu, 2024; Bedell & Gates, 2021; Howe et al., 2025).

Existing literature has extensively explored the role of citizen science in education, particularly its impact on learning outcomes and environmental engagement. Studies have shown that participation in citizen science can enhance students' understanding of ecological systems, promote environmental citizenship, and foster positive attitudes toward conservation. Furthermore, research has emphasized the value of immersive and experiential learning in shaping students' perceptions and motivations. Citizen science has also been linked to the development of critical thinking and collaborative skills, which are essential for addressing complex environmental challenges. However, much of this research focuses on measurable outcomes such as knowledge gain or participation rates, rather than exploring how students interpret and experience these activities

in their own contexts. As a result, there is limited insight into the subjective meanings and perceptions that students attach to citizen science experiences (Lüsse et al., 2022; Roche et al., 2020; Zhang et al., 2023; Day et al., 2022; McKinley et al., 2024).

Moreover, previous studies have highlighted the importance of community involvement and co-creation in citizen science, emphasizing the role of local knowledge and collaborative practices. Research has shown that integrating community perspectives can enhance the relevance and impact of educational programs, particularly in environmental and conservation contexts. Additionally, studies have examined different models of citizen science, including school-based, community-based, and immersive approaches, each offering unique benefits and challenges. Despite these contributions, there remains a gap in understanding how these diverse approaches influence students' perceptions and learning experiences. In particular, there is a lack of research that examines the intersection between classroom learning and real-world application from the students' perspective. Addressing this gap is crucial for designing educational strategies that effectively connect scientific knowledge with practical engagement (Tengö et al., 2021; Magnussen & Hod, 2023; Robinson et al., 2024; Hunter et al., 2023).

This study introduces a novel perspective by focusing on how community-based citizen science can bridge the gap between laboratory learning and real-life environmental engagement. It emphasizes the importance of understanding students' perceptions as a key factor in evaluating the effectiveness of educational interventions. Unlike previous studies that primarily assess outcomes, this research explores the experiential and interpretive dimensions of learning. By examining how students perceive and make meaning of their participation in citizen science, the study contributes to a deeper understanding of how education can foster meaningful connections between theory and practice. This approach also highlights the potential of citizen science to transform traditional educational models into more participatory and context-driven learning environments.

The central research problem of this study is to investigate how students perceive and experience community-based citizen science in bio-conservation education and how these perceptions influence their engagement with scientific and environmental issues. It argues that students' perceptions play a critical role in shaping the effectiveness of citizen science as an educational tool. It proposes that meaningful engagement occurs when students are able to connect classroom knowledge with real-world experiences, supported by collaborative and community-based learning environments. By addressing this problem, the study aims to contribute to the development of more effective and context-sensitive educational practices that bridge the gap between laboratory and life, ultimately enhancing students' understanding, motivation, and participation in conservation efforts (Harris et al., 2020; Leerhøi et al., 2024; Sousa et al., 2024).

RESEARCH METHODS

This study adopts a qualitative research design with an exploratory ethnographic approach to investigate students' perceptions of community-based citizen science in bio-conservation education. The qualitative design is selected because it enables an in-depth understanding of participants' lived experiences, interpretations, and meaning-making processes within authentic learning contexts. Ethnography is particularly appropriate as it allows the researcher to

capture the cultural and social dynamics that emerge when students engage in real-world scientific activities beyond the classroom. The study is conducted in an educational setting where citizen science programs are integrated into biology or environmental learning activities. This location is purposively selected due to its active implementation of community-based conservation projects, which provide rich opportunities for examining the interaction between formal education and real-life environmental engagement. Such contexts are considered highly relevant for understanding how experiential learning influences students' perceptions and participation in science (Lüsse et al., 2022; Vance-Chalcraft et al., 2022).

Data collection is carried out using multiple qualitative techniques to ensure comprehensive and in-depth data. These include participant observation, in-depth semi-structured interviews, and document analysis. Participant observation allows the researcher to directly examine students' involvement in citizen science activities, including their interactions with peers, instructors, and community members. Semi-structured interviews are conducted to explore students' perspectives, experiences, and reflections on their participation in conservation-related projects. Additionally, document analysis involves reviewing students' reports, field notes, and project outputs to understand how they interpret and represent their learning experiences. The use of multiple data sources enhances the richness of the data and supports triangulation, providing a more holistic understanding of the phenomenon under study, particularly in the context of experiential and community-based learning (Ballard et al., 2024; Williams et al., 2021).

Data analysis follows an interactive model consisting of data condensation, data display, and conclusion drawing and verification. In the data condensation stage, collected data are systematically reduced through coding, categorization, and identification of key themes related to student perceptions and engagement. The data are then organized and presented in visual and narrative forms, such as thematic matrices and descriptive accounts, to facilitate interpretation. Finally, conclusions are drawn and continuously verified through iterative comparison across data sources to ensure consistency and credibility. To ensure the trustworthiness of the findings, several validation strategies are employed, including triangulation of methods and data sources, prolonged engagement in the field, and member checking with participants to confirm the accuracy of interpretations. These procedures are essential in qualitative research to ensure credibility, dependability, and confirmability, particularly in studies examining complex learning experiences in citizen science contexts (Roche et al., 2020; Wu & Hsu, 2024).

RESULTS AND DISCUSSION

Results

The findings of this study reveal that students perceive community-based citizen science as a meaningful bridge between theoretical knowledge and real-life environmental experiences. Based on in-depth interviews, most informants expressed that participation in conservation activities helped them better understand biological concepts that were previously considered abstract. One student stated, "When we learned about ecosystems in class, it felt theoretical, but

when we collected data in the field, I could actually see how everything is connected.” Another informant noted, “It made me realize that science is not just in books, but something we can do in real life.” From the researcher’s interpretation, these responses indicate that citizen science activities enhance contextual understanding by linking classroom content with authentic environmental situations. Students begin to internalize scientific concepts not only cognitively but also experientially, suggesting a shift from passive learning to active engagement.

In addition, interview data show that participation in citizen science influences students’ environmental awareness and sense of responsibility. Several informants reported feeling more connected to nature and more motivated to engage in conservation efforts. One participant stated, “After joining the project, I feel more responsible for protecting the environment because I see the impact directly.” Another student explained, “Before this, I didn’t think much about conservation, but now I feel like I can contribute, even in small ways.” The researcher interprets these findings as evidence that citizen science fosters a sense of ownership and personal relevance, which are critical factors in promoting long-term environmental engagement. Students no longer perceive conservation as a distant or abstract issue but as something that directly involves them.

Findings from classroom and field observations further support these insights by illustrating how students engage with scientific practices during citizen science activities. During observations, students actively participated in data collection, environmental monitoring, and collaborative problem-solving. They demonstrated curiosity by asking questions, discussing findings with peers, and reflecting on their observations. In several instances, students showed increased enthusiasm compared to traditional classroom activities. The researcher observed that hands-on experiences, such as collecting environmental samples or identifying species, encouraged deeper engagement and sustained attention. From the researcher’s perspective, these behaviors indicate that experiential learning environments can significantly enhance student motivation and participation. The integration of real-world contexts appears to transform learning into a more interactive and meaningful process.

However, observational data also reveal variations in student engagement and perception. While many students found the activities meaningful, some perceived them as additional academic tasks rather than authentic learning experiences. For example, a few students were observed focusing primarily on completing assigned tasks without fully engaging in the underlying scientific inquiry. Informal conversations suggested that these students viewed the activities as requirements rather than opportunities for exploration. The researcher interprets this as an indication that the effectiveness of citizen science depends on how it is implemented and facilitated. Without clear connections to learning objectives and personal relevance, some students may struggle to fully appreciate the value of these experiences.

Furthermore, the findings highlight the importance of social interaction and collaboration in shaping students’ experiences. Observations show that students frequently worked in groups, sharing ideas, discussing findings, and supporting each other during field activities. This collaborative environment appeared to enhance learning by allowing students to co-construct knowledge and develop a shared understanding of environmental issues. One student remarked,

“Working with my friends made it easier to understand what we were doing because we could discuss and help each other.” The researcher interprets this as evidence that community-based approaches not only connect students with real-world contexts but also foster social learning processes. These interactions contribute to a more holistic learning experience, where cognitive, social, and emotional dimensions are interconnected.

Discussion

The findings of this study confirm that community-based citizen science serves as an effective bridge between theoretical knowledge and real-life environmental engagement, aligning with existing literature that emphasizes experiential and participatory learning. Previous studies have demonstrated that citizen science enhances students’ understanding of ecological systems and promotes meaningful engagement with environmental issues. The present findings support this view by showing that students develop deeper conceptual understanding when they participate in authentic field-based activities. Moreover, this study extends prior research by highlighting the role of perception in shaping learning outcomes, suggesting that the effectiveness of citizen science depends not only on participation but also on how students interpret and value their experiences (Ballard et al., 2024; Fraisl et al., 2022; Kelly et al., 2020).

In terms of environmental awareness and engagement, the findings are consistent with studies that highlight the transformative potential of immersive and hands-on learning experiences. Students’ increased sense of responsibility and motivation toward conservation aligns with research indicating that direct involvement in environmental activities fosters long-term engagement. Additionally, previous studies have shown that immersive citizen science experiences and real-world interactions significantly influence students’ attitudes and behaviors toward conservation. This study adds to the literature by demonstrating that emotional connection and personal relevance are key factors in sustaining this engagement, reinforcing the importance of designing meaningful and contextually grounded learning experiences (Howe et al., 2025; McKinley et al., 2024; Day et al., 2022).

However, the variation in student engagement observed in this study reveals important differences compared to some prior research that tends to report consistently positive outcomes. While many students experienced meaningful learning, others perceived citizen science activities as routine academic tasks. This finding aligns with literature emphasizing that student participation is influenced by program design, facilitation, and perceived relevance. It suggests that without clear connections between activities and learning objectives, students may fail to fully engage with the intended outcomes. Furthermore, studies on student perception and participation highlight the importance of aligning educational practices with students’ interests and expectations to maximize engagement (Wu & Hsu, 2024; Bedell & Gates, 2021; Zhang et al., 2023).

The collaborative and social dimensions of learning observed in this study are consistent with research emphasizing the role of community and interaction in citizen science. Previous studies have shown that collaboration between students, educators, and communities enhances learning outcomes and fosters a sense of shared responsibility. The findings confirm that peer interaction supports knowledge construction and engagement, while also highlighting the importance

of communication and teamwork in field-based learning. Additionally, research on co-created and community-driven citizen science underscores the value of integrating diverse perspectives and local knowledge into educational practices. This study contributes by illustrating how these dynamics operate in practice, reinforcing the importance of social learning processes in environmental education (Magnussen & Hod, 2023; Carson et al., 2021; Robinson et al., 2024; Tengö et al., 2021).

Finally, this study contributes to theoretical and practical discussions by emphasizing the need for integrated, student-centered approaches in citizen science education. Existing literature has highlighted both the opportunities and challenges of implementing citizen science in educational settings, including issues related to curriculum integration and teacher preparedness. The findings suggest that effective implementation requires not only experiential learning opportunities but also supportive instructional design and teacher understanding. This aligns with research on teacher experiences and the broader challenges of integrating citizen science into formal education. By addressing these issues, educators can better design programs that bridge the gap between laboratory learning and real-life application, ultimately enhancing students' scientific understanding and environmental engagement (Lüsse et al., 2022; Vance-Chalcraft et al., 2022; Sousa et al., 2024; Hunter et al., 2023).

CONCLUSION

This study reveals that the most significant finding lies in the ability of community-based citizen science to bridge the gap between theoretical learning and real-life environmental engagement. The key lesson is that students develop deeper understanding, stronger environmental awareness, and greater motivation when they are directly involved in authentic scientific practices. Learning becomes more meaningful when students can connect abstract biological concepts with real-world experiences, supported by collaboration and active participation. The strength of this study lies in its contribution to the growing body of knowledge on experiential and participatory learning by emphasizing the importance of students' perceptions in shaping educational outcomes. By adopting a qualitative and ethnographic perspective, this research provides a nuanced understanding of how citizen science functions not only as a pedagogical tool but also as a transformative learning experience that integrates cognitive, social, and emotional dimensions.

However, this study has several limitations that should be considered. The findings are based on a specific educational context, which may limit their generalizability to other settings with different cultural, institutional, or environmental conditions. Additionally, the qualitative nature of the study focuses on depth rather than breadth, which may not capture the full range of student experiences across diverse populations. Future research is recommended to explore similar approaches in varied contexts, including different educational levels and geographical locations. Employing mixed-methods or longitudinal designs could provide a more comprehensive understanding of how student perceptions and engagement evolve over time. Further studies may also investigate the role of teachers, curriculum design, and community partnerships in enhancing the effectiveness of citizen science in education.

REFERENCES

- Ballard, H., Lindell, A., & Jadallah, C. (2024). Environmental Education Outcomes of Community and Citizen Science: A Systematic Review of Empirical Research. *Environmental Education Research*, 30, 1007–1040. <https://doi.org/10.1080/13504622.2024.2348702>
- Bedell, K., & Gates, T. (2021). Do Ecological or Molecular Biological Citizen Science Projects Affect the Perceptions of Undergraduate Students Toward Pursuing Future Citizen Science? *Citizen Science: Theory and Practice*. <https://doi.org/10.5334/cstp.426>
- Carson, S., Rock, J., & Smith, J. (2021). Sediments and Seashores: A Case Study of Local Citizen Science Contributing to Student Learning and Environmental Citizenship. *Frontiers in Education*, 6. <https://doi.org/10.3389/educ.2021.674883>
- Day, G., Fuller, R., Nichols, C., & Dean, A. (2022). Characteristics of Immersive Citizen Science Experiences That Drive Conservation Engagement. *People and Nature*. <https://doi.org/10.1002/pan3.10332>
- Fantinelli, S., Cortini, M., Di Fiore, T., Iervese, S., & Galanti, T. (2024). Bridging the Gap Between Theoretical Learning and Practical Application: A Qualitative Study in the Italian Educational Context. *Education Sciences*. <https://doi.org/10.3390/educsci14020198>
- Fraisl, D., Hager, G., Bedessem, B., Gold, M., Hsing, P., Danielsen, F., Hitchcock, C., Hulbert, J., Piera, J., Spiers, H., Thiel, M., & Haklay, M. (2022). Citizen Science in Environmental and Ecological Sciences. *Nature Reviews Methods Primers*, 2. <https://doi.org/10.1038/s43586-022-00144-4>
- Gormally, C., & Heil, A. (2022). A Vision for University Biology Education for Non-science Majors. *CBE Life Sciences Education*, 21. <https://doi.org/10.1187/cbe.21-12-0338>
- Harris, E., Dixon, C., Bird, E., & Ballard, H. (2020). For Science and Self: Youth Interactions With Data in Community and Citizen Science. *Journal of the Learning Sciences*, 29, 224–263. <https://doi.org/10.1080/10508406.2019.1693379>
- Howe, A., Nguyen, T., O'Connor, P., Woodward, A., Clarke, S., Ducker, N., Dilger, K., & Fagan-Jeffries, E. (2025). Catching 'the Bug': Investigating Insects Through School-based Citizen Science Increases Intentions for Environmental Activities in Students and Teachers. *Austral Entomology*, 64. <https://doi.org/10.1111/aen.70004>
- Hunter, D., Newman, G., & Balgopal, M. (2023). What's in a Name? The Paradox of Citizen Science and Community Science. *Frontiers in Ecology and the Environment*. <https://doi.org/10.1002/fee.2635>
- Kelly, R., Fleming, A., Pecl, G., Von Gönner, J., & Bonn, A. (2020). Citizen Science and Marine Conservation: A Global Review. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 375. <https://doi.org/10.1098/rstb.2019.0461>
- Leerhøi, F., Rytter, M., Lillemark, M., Randeris, B., Rix, C., Olesen, J., Olsen, M., Møller, P., Lundholm, N., Knudsen, S., & Tøttrup, A. (2024). Exploring the Potential of Extreme Citizen Science With Danish High School Students Using Environmental DNA for Marine Monitoring. *Frontiers in Marine Science*. <https://doi.org/10.3389/fmars.2024.1347298>
- Lüsse, M., Brockhage, F., Beeken, M., & Pietzner, V. (2022). Citizen Science and Its Potential for Science Education. *International Journal of Science Education*, 44, 1120–1142. <https://doi.org/10.1080/09500693.2022.2067365>

- MacPhail, V., & Colla, S. (2020). Power of the People: A Review of Citizen Science Programs for Conservation. *Biological Conservation*, 249, 108739. <https://doi.org/10.1016/j.biocon.2020.108739>
- Magnussen, R., & Hod, Y. (2023). Bridging Communities and Schools in Urban Development: Community and Citizen Science. *Instructional Science*, 51, 887–911. <https://doi.org/10.1007/s11251-023-09641-9>
- McKinley, E., Garcia, M., Palacios, M., Nichols, C., Bhattacharjee, A., & Macreadie, P. (2024). Immersive Citizen Science Experiences and Their Role in Changing Perceptions of Coastal Wetlands. *People and Nature*. <https://doi.org/10.1002/pan3.10728>
- Robinson, D., Delany, J., & Sugden, H. (2024). Beyond Science: Exploring the Value of Co-created Citizen Science for Diverse Community Groups. *Citizen Science: Theory and Practice*. <https://doi.org/10.5334/cstp.682>
- Roche, J., Bell, L., Galvão, C., Golumbic, Y., Kloetzer, L., Knob, N., Laakso, M., Lorke, J., Mannion, G., Massetti, L., Mauchline, A., Pata, K., Ruck, A., Taraba, P., & Winter, S. (2020). Citizen Science, Education, and Learning: Challenges and Opportunities. *Frontiers in Sociology*, 5. <https://doi.org/10.3389/fsoc.2020.613814>
- Sousa, L., Kenneally, C., Golumbic, Y., Martin, J., Preston, C., Rutledge, P., & Motion, A. (2024). Teacher Experiences and Understanding of Citizen Science in Australian Classrooms. *PLOS ONE*, 19. <https://doi.org/10.1371/journal.pone.0312680>
- Tengö, M., Austin, B., Danielsen, F., & Fernández-Llamazares, Á. (2021). Creating Synergies Between Citizen Science and Indigenous and Local Knowledge. *Bioscience*, 71, 503–518. <https://doi.org/10.1093/biosci/biab023>
- Vance-Chalcraft, H., Hurlbert, A., Styrsky, J., Gates, T., Bowser, G., Hitchcock, C., Reyes, M., & Cooper, C. (2022). Citizen Science in Postsecondary Education: Current Practices and Knowledge Gaps. *Bioscience*, 72, 276–288. <https://doi.org/10.1093/biosci/biab125>
- Williams, K., Hall, T., & O'Connell, K. (2021). Classroom-based Citizen Science: Impacts on Students' Science Identity, Nature Connectedness, and Curricular Knowledge. *Environmental Education Research*, 27, 1037–1053. <https://doi.org/10.1080/13504622.2021.1927990>
- Wu, Y., & Hsu, W. (2024). What Improves Students' Participation in a School-based Citizen Science Project? Through the Lens of Practitioners. *International Journal of Science Education*, 47, 87–106. <https://doi.org/10.1080/09500693.2024.2311088>
- Yan, S., Race, A., Ballard, H., Bird, E., Henson, S., Portier, E., Lindell, A., Khanaposhtani, M., Miller, J., & Schectman, E. (2023). How Can Participating in a Forest Community and Citizen Science Program Support Elementary School Students' Understanding of Socio-ecological Systems? *Sustainability*. <https://doi.org/10.3390/su152416832>
- Zhang, E., Hundley, C., Watson, Z., Farah, F., Bunnell, S., & Kristensen, T. (2023). Learning by Doing: A Multi-level Analysis of the Impact of Citizen Science Education. *Science Education*. <https://doi.org/10.1002/sce.21810>