

Inquiry-based Ethnoecological Conservation Approach to Improve Students' Critical Thinking Skills

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Article Info

Article History

Received: March 2024

Revised: July 2024

Published: September 2024

Keywords

Ethnoecological

conservation;

Inquiry-based learning;

Critical thinking skills;

Environmental education

 [10.33394/ijete.v1i2.11240](https://doi.org/10.33394/ijete.v1i2.11240)

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Abstract

This study explores the effectiveness of an inquiry-based ethnoecological conservation approach in enhancing critical thinking skills among students. Amidst growing concerns over environmental degradation, the integration of ethnoecological knowledge within educational frameworks emerges as a potent tool for fostering environmental stewardship and critical thinking. This research adopts a mixed methods design, engaging 45 secondary school students in a two-month pedagogical intervention that blends inquiry-based learning with ethnoecological insights. The intervention's impact on critical thinking was assessed using pretest-posttest analysis, supplemented by qualitative insights from student interviews. Quantitative results demonstrate a significant improvement in students' critical thinking skills post-intervention, with statistical analysis revealing a notable increase in mean scores and a reduction in score variability. This indicates not only an enhancement in critical thinking abilities but also a homogenization of skills across the participant group, underscoring the universal efficacy of the approach. Qualitative findings further enrich these results, with students reporting a deeper understanding of environmental issues, a stronger connection to cultural heritage, and a heightened sense of responsibility towards conservation efforts. The study highlights the transformative potential of integrating indigenous knowledge systems into environmental education, advocating for a pedagogical shift towards more inclusive, culturally relevant learning frameworks. By engaging students in a contextually rich exploration of ecological and cultural interconnections, the inquiry-based ethnoecological approach proves effective in cultivating critical thinking, thereby equipping students with the cognitive tools necessary to navigate and address complex environmental challenges. This research contributes to the evolving discourse on environmental education, offering valuable insights into the role of ethnoecology and inquiry-based learning in developing critical thinking skills and fostering a generation of informed and engaged environmental stewards.

How to Cite: Musah, E., & Wangila, C. (2024). Inquiry-based Ethnoecological Conservation Approach to Improve Students' Critical Thinking Skills. *International Journal of Ethnoscience and Technology in Education*, 1(2), 97-115. doi:<https://doi.org/10.33394/ijete.v1i2.11240>

INTRODUCTION

Ethnoecology, a field that explores the intricate connections between human societies and their environments, plays a pivotal role in understanding the interplay between cultures and ecological systems. This discipline delves into how indigenous knowledge systems and practices can inform modern ecological understanding and conservation efforts (Kunwar et al., 2013). As societies grapple with escalating environmental challenges, the integration of ethnoecological knowledge into educational settings becomes increasingly significant. This integration not only enriches students' comprehension of conservation efforts but also fosters a more profound appreciation for the cultural contexts within which these efforts are situated (Berkes & Turner, 2006). Traditional teaching methods, however, often fail to leverage the full potential of ethnoecological knowledge in fostering critical thinking skills among students, particularly in understanding the complex relationships between humans and their environments (Ungirwalu et al., 2017).

In educational settings, the importance of incorporating environmental knowledge rooted in local traditions cannot be overstated. Such knowledge provides a contextual framework that enhances students' understanding of ecological principles and conservation practices (Berkes & Turner, 2006). However, many educational systems still rely heavily on traditional teaching methods that prioritize rote learning over critical thinking and fail to engage students with the rich, contextual knowledge inherent in their cultural backgrounds (Ungirwalu et al., 2017). This oversight is particularly problematic in the context of environmental education, where understanding the nuanced interactions between humans and their environments is crucial. The deficiency in critical thinking skills among students regarding ecological interconnections presents a significant challenge that needs immediate attention (Ungirwalu et al., 2017).

Given the importance of ecology as a field of study, it is essential to equip students with the ability to critically analyze the dynamic relationships within natural systems. This capability is fundamental for fostering a generation of environmentally literate individuals who can navigate and address complex environmental challenges (Ungirwalu et al., 2017). Traditional educational approaches often fail to provide students with the necessary skills to critically engage with ecological content, resulting in a superficial understanding of environmental issues. This gap highlights the need for innovative educational strategies that not only convey ecological knowledge but also cultivate critical thinking skills and a deeper understanding of the interconnectedness of natural systems.

In response to this educational gap, the inquiry-based learning (IBL) model emerges as a promising approach to incorporate ethnoecological conservation into the curriculum (Kunwar et al., 2006). IBL is an educational strategy that encourages students to learn by engaging in inquiry-based activities, fostering a deeper understanding of the subject matter through exploration and discovery. By immersing students in questions and scenarios deeply embedded in their cultural and ecological contexts, IBL promotes active learning and critical thinking. This approach makes education more relevant and empowering, enabling students

to contribute meaningfully to local conservation endeavors (Kunwar et al., 2006). Moreover, IBL aligns with the idea that integrating indigenous knowledge with scientific insights can offer new dimensions for sustainable development, providing effective tools against climate change and economic instability (Malik & Singh, 2019).

The integration of indigenous knowledge and ethnoscientific approaches into conservation frameworks is increasingly recognized as crucial at both international and national policy levels (Rist & Dahdouh-Guebas, 2006). This recognition underscores the value of incorporating local wisdom into conservation practices, highlighting the overlap between traditional ecological knowledge and modern conservation efforts. Studies have shown that ethnoecological knowledge can significantly enhance sustainable resource management, emphasizing the importance of local wisdom in these practices (Paneque-Gálvez et al., 2018). The sharing and utilization of ethnoecological knowledge in various contexts, such as medicinal plant management in Nepal (Kunwar et al., 2013), rock kangaroo ecology in Australia (Telfer & Garde, 2006), and the conservation of the Southern River Terrapin in Malaysia (Chen, 2017), underscore the diverse applications and benefits of integrating traditional wisdom into conservation strategies.

Ethnoecology offers a rich tapestry of knowledge that, when integrated into educational frameworks and conservation strategies, not only enhances critical thinking skills but also fosters a deeper appreciation for the intricate relationships between humans and their environment. By bridging the gap between traditional knowledge and modern science, ethnoecology paves the way for more holistic and sustainable approaches to environmental stewardship and conservation. This integration not only contributes to the evolving discourse on environmental education but also provides valuable insights into the role of ethnoecology and inquiry-based learning in developing critical thinking skills and fostering a generation of informed and engaged environmental stewards.

The integration of ethnoecological knowledge into educational settings through inquiry-based learning presents a unique opportunity to enhance students' critical thinking skills and their understanding of ecological systems. By drawing on indigenous knowledge and embedding learning within cultural and ecological contexts, educators can create more engaging and effective learning experiences. This approach not only benefits students by providing them with the cognitive tools necessary to address complex environmental challenges but also enriches conservation efforts by incorporating valuable traditional knowledge into modern practices. As environmental issues continue to escalate, the need for innovative educational strategies that foster critical thinking and sustainability becomes ever more pressing, underscoring the importance of ethnoecology in contemporary education.

Aim of the Study

The primary aim of this study is to explore the effectiveness of an inquiry-based ethnoecological conservation approach in improving students' critical thinking skills. Specifically, the research seeks to: (1) assess the impact of this pedagogical method on students' critical thinking skills, (2) understand how engagement with local ecological

knowledge and practices influences students' critical thinking skills, and (3) identify the potential role of this approach in promoting environmental stewardship among youth.

Novelty of the Research

Recent research highlights the significance of integrating local and indigenous knowledge systems into environmental education to improve ecological awareness and conservation efforts. This integration not only enhances learning frameworks but also cultivates a stronger connection with the environment (Kefalew et al., 2022). Studies have demonstrated that inquiry-based learning is effective in enhancing critical thinking and problem-solving skills across various educational levels (Minner et al., 2009). By combining ethnoecology with inquiry-based methods, there is a unique opportunity to advance conservation education by utilizing the rich ethnoecological heritage of communities to enhance critical thinking and conservation outcomes among students (Pfeiffer & Uril, 2003).

The innovative combination of inquiry-based learning with ethnoecological knowledge represents a substantial contribution to environmental education and conservation. Unlike previous studies, this research specifically focuses on using local cultural and ecological knowledge as a basis for inquiry, aiming to tap into the wealth of ethnoecological wisdom within communities to enhance critical thinking and conservation results among students (Braga & Schiavetti, 2013). By integrating indigenous knowledge into educational practices, such as through inquiry-based learning, a more holistic and culturally sensitive approach to conservation education can be achieved, fostering a deeper understanding and appreciation of the environment (Thoron & Burleson, 2014).

Integrating ethnoecological knowledge and inquiry-based learning not only enhances conservation education but also encourages a more inclusive and diverse approach to environmental learning. By recognizing and integrating local perspectives and traditional ecological knowledge, students can develop a deeper connection with nature and a stronger sense of stewardship towards the environment (Williams et al., 2021). This approach aligns with the increasing acknowledgment of the importance of community involvement in conservation efforts and the necessity to respect and integrate diverse knowledge systems into educational frameworks (Nugroho & Zulfiani, 2021). Ultimately, by merging ethnoecology with inquiry-based methods, educators can establish a more engaging and effective learning environment that nurtures critical thinking, cultural appreciation, and environmental conservation (Hutapea et al., 2020).

Brief Theoretical Background

Ethnoecology, as a framework, provides a profound lens through which the intricate relationships between diverse cultures and their natural environments can be understood. This interdisciplinary field combines insights from anthropology, ecology, and cultural studies to explore how different societies perceive and interact with their natural surroundings (Shaffer, 2014). A key component within ethnoecology is Traditional Ecological Knowledge (TEK), which encompasses the cumulative body of knowledge, practices, and

beliefs developed by indigenous and local communities through generations of interaction with their environment (Isaac et al., 2018). TEK is crucial for ecosystem management and biodiversity conservation as it offers context-specific insights and sustainable practices that have been refined over centuries. By integrating TEK into environmental education, students gain a more nuanced perspective on conservation issues, enabling them to explore local environmental challenges through the lens of cultural heritage (Olson, 2013). This integration not only enriches the educational content but also helps students build a stronger, more personal connection to the subject matter, thus promoting active learning and enhancing critical thinking skills (Shawoo & Thornton, 2019).

Inquiry-Based Learning (IBL) strategies, which are characterized by a student-centered approach, further complement the integration of ethnoecological knowledge into education. IBL encourages learners to actively engage with questions and problems, fostering a deeper understanding of the subject matter through exploration and discovery (Singleton et al., 2021). This approach aligns with constructivist theories of education, which posit that knowledge is constructed through experiences and interactions rather than passively received (Miyaji & Fukui, 2020). By engaging students in the process of inquiry, IBL promotes critical thinking and problem-solving skills, as students are required to analyze, synthesize, and evaluate information. Studies have demonstrated that the implementation of IBL in educational settings can lead to improved learning outcomes, enhanced performance, and the development of essential academic skills (Ariza et al., 2021). This makes IBL an effective pedagogical strategy for fostering deep, meaningful learning experiences.

The amalgamation of ethnoecological knowledge with IBL strategies offers a comprehensive educational approach that enables students to explore, reflect, and actively participate in addressing conservation challenges. This integrated approach not only enhances students' understanding of environmental issues but also makes the learning process more engaging and relevant (Turner & Spalding, 2013). By combining TEK with IBL, educators can provide students with opportunities to develop a deeper connection to environmental challenges and engage more actively in conservation efforts (Gruberg et al., 2022). For instance, students might investigate local environmental problems by drawing on both scientific methods and traditional knowledge, leading to a more holistic and culturally informed understanding of conservation. This method not only broadens students' perspectives but also fosters a sense of responsibility and stewardship towards their natural environment.

In conclusion, integrating ethnoecological knowledge with IBL strategies presents a promising approach to enhancing students' critical thinking skills and understanding of conservation issues. This combined approach enriches the educational experience by fostering a more sustainable relationship between individuals, communities, and their natural environments (Chandra, 2014). By leveraging the strengths of both TEK and IBL, educators can create a learning environment that is not only informative but also transformative, equipping students with the cognitive tools and cultural insights necessary to navigate and

address complex environmental challenges. This integration also underscores the value of culturally relevant education, which respects and incorporates the wisdom of indigenous and local communities, thereby promoting a more inclusive and equitable approach to environmental stewardship and education.

METHODS

Research Design

To align with the multifaceted objectives of this study, a mixed methods research approach was adopted, integrating both quantitative and qualitative methodologies to provide a comprehensive understanding of the inquiry-based ethnoecological conservation approach's effectiveness in enhancing students' critical thinking skills. This design allows for the exploration of quantitative data to assess the impact of the intervention on critical thinking skills quantitatively, while qualitative data offers insights into the students' experiences and perceptions, shedding light on how engagement with local ecological knowledge and practices influences their problem-solving skills and environmental stewardship. The quantitative component involved a pretest-posttest design to measure changes in critical thinking skills among the participants, whereas the qualitative aspect utilized interviews to capture in-depth reflections on the learning process and its outcomes. This combination of methods enables a robust analysis of the intervention's effectiveness from multiple perspectives, ensuring a thorough understanding of its impacts.

In detail, the quantitative research phase involved the application of statistical tools to analyze pretest and posttest scores of critical thinking skills, allowing for an objective evaluation of the learning intervention's effect. On the other hand, the qualitative phase engaged in thematic analysis of interview transcripts to identify recurring themes and patterns regarding students' engagement with the curriculum and its influence on their critical thinking and problem-solving abilities. By employing a mixed methods design, this study leverages the strengths of both quantitative and qualitative research, facilitating a more nuanced and holistic understanding of the pedagogical intervention's impacts. This approach not only answers the 'what' and 'how much' questions through quantitative analysis but also addresses the 'how' and 'why' aspects through qualitative insights, thereby enriching the study's findings.

Participants and Ethical Consideration

The study involved 45 students from a secondary school in Africa, with a demographic composition of 60% male and 40% female participants. This diverse group was chosen to ensure a broad representation of perspectives and experiences with the ethnoecological conservation material. The selection of participants was guided by the aim to examine the inquiry-based learning intervention's impact across a varied student population, reflecting a realistic educational setting. To adhere to ethical standards involving human participants, the study obtained informed consent from all participants or their guardians where applicable, ensuring they were fully aware of the study's purpose, the nature of their involvement, and

their right to withdraw at any time without penalty. The research complied with all institutional and international guidelines on ethical research conduct, emphasizing respect, confidentiality, and the minimization of potential harm to the participants. This ethical compliance was integral to the research design, ensuring the protection of participants' rights and well-being throughout the study.

Learning Intervention

The core of this research centered on the implementation of an inquiry-based ethnoecological conservation approach as the learning intervention over a two-month period. This pedagogical strategy was integrated into the existing environmental conservation curriculum, designed to actively involve students in the learning process by encouraging them to ask questions, explore, and engage with ethnoecological knowledge and practices. This pedagogical strategy aimed to foster a deeper understanding of the complex relationships between local communities and their environments, emphasizing critical thinking and problem-solving skills relevant to conservation efforts.

The intervention's structure was carefully developed to ensure progressive engagement with the material, facilitating a scaffolded learning experience that built on students' existing knowledge and interests. Through this approach, students were not only expected to enhance their critical thinking skills but also to develop a stronger appreciation for and commitment to environmental stewardship, grounded in an understanding of indigenous knowledge and conservation practices.

Research Procedures

The research followed a systematic procedure beginning with the baseline assessment of students' critical thinking skills using a pretest. This initial phase established a control measure against which the post-intervention outcomes could be evaluated. Following the pretest, the two-month learning intervention was implemented, during which students engaged with the inquiry-based ethnoecological conservation approach. Throughout this period, qualitative data were collected through observations and interviews, capturing students' interactions with the material and their evolving perceptions and problem-solving strategies. Upon completion of the intervention, a posttest was administered to assess any changes in critical thinking skills. The qualitative data collection continued post-intervention, focusing on students' reflections on the learning experience and its impact on their understanding and attitudes towards environmental conservation. This comprehensive procedure ensured the collection of both quantitative and qualitative data at multiple points, providing a rich dataset for analysis.

Instruments and Analysis

The research employed two primary instruments for data collection: a critical thinking skills test and an interview guide. The critical thinking skills test was designed to quantitatively assess students' abilities in analysis, evaluation, inference, and explanation—

key components of critical thinking as identified in the educational literature. This test was administered as both a pretest and posttest, allowing for a comparative analysis of students' critical thinking skills before and after the intervention. The design of the test was based on established critical thinking assessment frameworks, ensuring validity and reliability in measuring the intended cognitive skills.

The qualitative component of the study utilized an interview guide structured around open-ended questions to elicit in-depth responses from students regarding their experiences with the inquiry-based ethnoecological conservation approach. These interviews aimed to explore students' perceptions, reflections, and the subjective impact of the intervention on their learning and critical thinking skills. The guide was developed to prompt discussion on specific aspects of the learning experience, such as engagement with ethnoecological knowledge, the process of inquiry-based learning, and any changes in attitudes or understandings related to environmental conservation.

For the analysis of quantitative data, descriptive statistics were employed to summarize the pretest and posttest scores, providing an overview of the distribution, central tendency, and variability of students' critical thinking skills. Comparative analysis, using paired sample t-tests, was conducted to detect statistically significant differences in the critical thinking scores before and after the intervention. This analysis allowed for a clear, objective assessment of the intervention's effectiveness in enhancing students' critical thinking skills.

The qualitative data from the interviews were analyzed using thematic analysis, a method for identifying, analyzing, and reporting patterns within data. This process involved transcribing interviews, coding responses for recurring themes, and interpreting these themes to understand the nuances of students' experiences and perceptions. The thematic analysis aimed to complement the quantitative findings by providing deeper insights into how the inquiry-based ethnoecological conservation approach influenced students' learning processes, engagement, and critical thinking development. Together, these instruments and methods of analysis provided a comprehensive evaluation of the intervention's impact, blending statistical evidence with qualitative depth to offer a holistic view of its educational outcomes.

RESULTS AND DISCUSSION

The study presented seeks to examine the impact of an inquiry-based ethnoecological conservation approach on improving students' critical thinking skills. The integration of ethnoecological knowledge into educational frameworks is posited as a novel strategy for enhancing critical thinking and conservation outcomes among students. This comprehensive quantitative analysis delves into the results presented in Table 1, Figure 1, and Table 2.

Table 1. Results of descriptive data analysis of students' critical thinking skills

Group	N	Mean	SD	SE	Coeff. of Variation
Pretest	45	56.711	11.506	1.715	0.203
Posttest	45	77.000	7.154	1.066	0.093

Table 1 provides a clear indication of the intervention's effectiveness, as evidenced by the increase in mean scores of students' critical thinking skills from the pretest (Mean = 56.711, SD = 11.506) to the posttest (Mean = 77.000, SD = 7.154). The reduction in the standard deviation and the coefficient of variation in the posttest scores suggests not only an improvement in the overall critical thinking ability of the students but also a homogenization of their skill levels, indicating a universally effective teaching approach. The significant increase in mean scores and the reduction in variability underscore the intervention's capacity to enhance critical thinking skills across a diverse student group.

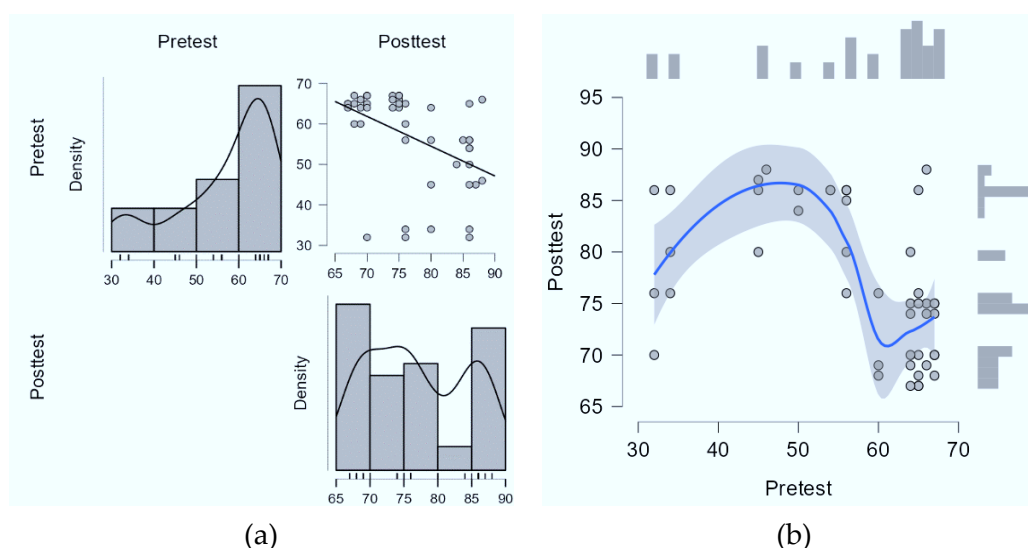


Figure 1. Descriptive plots of students' critical thinking skills: (a) correlation plots, and (b) scatter plots

The descriptive plots, comprising correlation and scatter plots, visually reinforce the quantitative findings by illustrating the distribution and relationship between pretest and posttest scores. These plots depict a positive correlation between the two sets of scores, suggesting that students who started with higher baseline critical thinking skills also showed significant improvement post-intervention, although this improvement is observed across all levels of initial ability. The quantitative analysis of Figure 1, provide a robust framework for understanding the nuances of how an inquiry-based ethnoecological conservation approach influences students' critical thinking skills. The analysis underscores the potential for such pedagogical strategies to foster critical thinking in a way that is both effective across a broad student population and sensitive to individual variations in learning and improvement.

Table 2. Statistical analysis results using paired samples t-test

Measure	t	df	p	VS-MPR*	Mean Diff.	SE Diff.	SE Cohen's d
Pretest-posttest	-8.458	44	< .001	1.775×10 ⁺⁸	-20.289	2.399	0.341

*Vovk-Sellke Maximum p -Ratio (VS-MPR): Based on a two-sided p -value, the maximum possible odds in favor of H_1 over H_0 equals $1/(-e p \log(p))$ for $p \leq .37$

The results detailed in Table 2, stemming from the statistical analysis with paired samples t-test, offer a robust quantitative assessment of the intervention's impact on students' critical thinking skills. The t-test, which compares the means of two related groups (in this case, the pretest and posttest scores of the same students), resulted in a t-value of -8.458 with degrees of freedom (df) of 44, indicating a highly significant difference between the two sets of scores with a p-value of less than .001. This level of significance far surpasses conventional thresholds (e.g., $p < .05$), unequivocally rejecting the null hypothesis that there would be no difference in critical thinking skills before and after the intervention. The Mean Difference of -20.289 (with a Standard Error (SE) Difference of 2.399) signifies that, on average, students' critical thinking skills scores increased by approximately 20 points from the pretest to the posttest. This notable increase not only signifies the effectiveness of the inquiry-based ethnoecological conservation approach but also emphasizes the potential of this pedagogical method in significantly enhancing critical thinking abilities among students.

The Cohen's d value, a measure of effect size, was calculated to be 0.341, indicating a moderate effect size. This metric helps in understanding the practical significance of the intervention, suggesting that the observed improvement in critical thinking skills, while statistically significant, has a moderate impact when considering the variation within the sample. Furthermore, the Vovk-Sellke Maximum p-Ratio (VS-MPR) stands at 1.775×10^{-8} , offering a nuanced metric for interpreting the p-value's strength against the null hypothesis; in this context, it provides strong evidence favoring the alternative hypothesis that the inquiry-based ethnoecological conservation approach does indeed have a significant effect on improving students' critical thinking skills. This comprehensive statistical analysis substantiates the pedagogical intervention's efficacy, underlining its value in educational settings where enhancing critical thinking is a key objective. The results serve not only as a testament to the intervention's success but also as a compelling argument for the broader application of inquiry-based learning models, especially those that integrate ethnoecological knowledge, in fostering essential cognitive skills in science educational curricula.

Furthermore, qualitative data findings from the research were obtained through interviews with students. The interviews aim to provide insights into how the inquiry-based ethnoecological conservation approach influenced students' critical thinking skills and their views on environmental stewardship. Excerpts from interviews from four students as a sample (student codes: A-9, A-14, A-24, A-38) are presented in Table 3.

Table 3. Excerpts from interviews with students

No	Student	Excerpt from the interview
1	Student 1: "A-9" - Age 15	On critical thinking skills: <i>"Before the program, I never really questioned why certain plants were disappearing or why we should even care. But after learning about how our ancestors used these plants and their roles in our ecosystem, I started thinking more critically about the changes happening around us. I began</i>

No	Student	Excerpt from the interview
		<p>asking more questions in class, especially about how we can solve these problems."</p> <p>On environmental stewardship:</p> <p>"I feel a stronger connection to my community's traditions now. It's like I have a role in protecting these plants and animals because they're part of our heritage. I've started helping my family more with our garden, using some of the traditional methods we learned about."</p>
2	Student 2: "A-14" - Age 16	<p>On critical thinking skills:</p> <p>"The project made me realize that there's so much I don't know about our local environment. Analyzing the different ways plants are used for medicine and how those practices are sustainable made me think differently about conservation. It's not just about saving animals; it's about preserving knowledge and ways of life."</p> <p>On environmental stewardship:</p> <p>"I've become more vocal about environmental issues in my community. After learning how everything is connected, I started a club at school to promote recycling and conservation projects. I think it's important that we, as youth, take up the mantle of stewardship for our environment."</p>
3	Student 3: "A-24" - Age 14	<p>On critical thinking skills:</p> <p>"Working on the projects, I had to think outside the box to come up with solutions for conserving water in our school garden using traditional methods. It was challenging but rewarding to see how our ideas could come to life and actually work. It made me appreciate the wisdom in traditional practices and think critically about applying them to modern problems."</p> <p>On environmental stewardship:</p> <p>"I never paid much attention to how my actions impacted the environment before. But through this program, I learned the importance of every species and how indigenous knowledge can help us live more sustainably. Now, I'm more conscious about reducing waste and using resources wisely."</p>
4	Student 4: "A-38" - Age 17	<p>On critical thinking skills:</p> <p>"Discussing the different perspectives on conservation in class opened my eyes to the complexity of environmental issues. It wasn't just about finding the 'right' answer but understanding the different factors at play. This approach made me more analytical and skeptical of simple solutions to complex problems."</p> <p>On environmental stewardship:</p> <p>"Learning about the environmental practices of our ancestors made me proud of my heritage. It inspired me to learn more and share this knowledge with others. I think spreading awareness is the first step towards fostering a sense of responsibility towards the environment among my peers."</p>

The integration of an inquiry-based ethnoecological conservation approach in educational settings has been demonstrated to enhance students' critical thinking skills and deepen their understanding of environmental stewardship rooted in ethnoecological knowledge. This approach not only fosters improved critical thinking abilities but also cultivates a more nuanced perspective on environmental issues, emphasizing the importance of culturally relevant knowledge in promoting environmental awareness and action (Furtak et al., 2012). Previous studies have emphasized the effectiveness of combining inquiry-based learning with ethnoecology to enhance student learning outcomes. While the definition of inquiry-based teaching may vary, research has indicated a positive correlation between such teaching methods and enhanced student learning, particularly when students actively engage in analyzing complex environmental issues through the lens of their cultural and ecological heritage (Berkes et al., 2000).

Furthermore, various studies have illustrated the preservation of ethnoecological knowledge, demonstrating how local wisdom and traditional practices persist despite changing environments and constraints. This continuity of ethnoecological knowledge highlights its significance in conservation efforts and sustainable environmental practices (Rahayu et al., 2021). By bridging the traditional knowledge gap with modern conservation approaches, ethnoecology contributes to a more comprehensive understanding of environmental stewardship. This integration of indigenous knowledge systems with scientific practices is recognized as a crucial step towards effective natural resource management and biodiversity conservation (Rist & Dahdouh-Guebas, 2006). The synthesis of findings from this study with relevant previous research underscores the value of incorporating ethnoecological perspectives in educational settings to enhance critical thinking skills and promote a deeper understanding of environmental stewardship. By acknowledging and integrating diverse knowledge systems, educators and conservationists can collaborate towards a more inclusive and effective approach to environmental education and conservation.

The research findings indicate that the inquiry-based ethnoecological conservation approach leads to a reduction in the variability of students' critical thinking skills post-intervention, suggesting universal benefits across diverse learning backgrounds. This standardization of skill levels highlights the approach's capacity to enhance critical thinking abilities for all students, irrespective of their initial proficiency levels. It emphasizes the significance of adaptive and inclusive educational strategies that acknowledge and utilize the diverse cultural and ecological knowledge within student communities (Duran & Dökme, 2016).

Qualitative insights from student interviews reveal the profound impact of this pedagogical approach on students' attitudes towards environmental conservation. Students expressed a stronger connection to their community's traditions and a heightened sense of responsibility towards environmental stewardship. These qualitative reflections not only validate the quantitative results but also shed light on how the intervention fosters a personal connection to conservation efforts, thereby boosting students' motivation and dedication to

safeguarding their natural surroundings (Bennett, 2016). Previous studies have shown that inquiry-based learning approaches, such as the one employed in this research, positively contribute to enhancing students' critical thinking skills. The findings align with existing literature that emphasizes the importance of critical thinking in problem-solving and knowledge improvement (Cao, 2022). Additionally, research on the impact of inquiry-based learning on critical thinking skills has demonstrated significant improvements in students' abilities, supporting the notion that such pedagogical methods are effective in cultivating critical thinking (Ghaemi & Mirsaeed, 2017).

The statistical analysis conducted through a paired samples t-test in the current research highlights the significant improvements in students' critical thinking skills following the implementation of the inquiry-based ethnoecological conservation approach. The moderate effect size observed indicates a substantial positive impact on students' abilities to critically analyze, evaluate, and engage with environmental issues. The Vovk-Sellke Maximum p-Ratio further strengthens the argument for the adoption of this pedagogical approach, providing strong evidence of its effectiveness in enhancing critical thinking skills. Such statistical reinforcement is essential for establishing the inquiry-based ethnoecological conservation approach as a validated and effective educational strategy, worthy of broader application in diverse educational settings. These findings are pivotal for educators and curriculum developers aiming to integrate strategies that effectively foster critical thinking and problem-solving skills within the realm of environmental education (Minner et al., 2009). Previous studies have underscored the importance of inquiry-based learning approaches in enhancing critical thinking skills. Research synthesis spanning from 1984 to 2002 has shown the relevance and impact of inquiry-based science instruction on student learning outcomes (Minner et al., 2009). Additionally, studies have demonstrated that inquiry-based teaching practices can lead to improvements in students' learning achievements and critical thinking abilities (Furtak et al., 2012). Furthermore, the incorporation of inquiry-based learning in various educational settings has been associated with positive outcomes, including enhanced critical thinking skills and increased engagement with learning materials (Deák et al., 2021). The effectiveness of inquiry-based approaches in promoting critical thinking has been further supported by research focusing on different educational contexts. Studies have shown that inquiry-based education can improve students' performance levels and foster positive emotions towards learning (Ruzaman & Rosli, 2020). Moreover, the utilization of inquiry-based teaching practices has been linked to increased critical thinking dispositions and skills among pre-service teachers (Mamun, 2022).

The thematic analysis of interview data offers a nuanced understanding of how the intervention influences students' learning processes and attitudes towards conservation. Themes of increased curiosity, a stronger connection to cultural heritage, and a proactive stance on environmental issues emerged, highlighting the multifaceted benefits of integrating ethnoecology with inquiry-based learning. These qualitative insights complement the quantitative data, providing a comprehensive view of the intervention's impact on students'

development as critical thinkers and environmentally responsible citizens. Moreover, the study reveals the potential of ethnoecological knowledge to enrich science curricula by providing students with contextually relevant examples of sustainable practices. This alignment with local traditions and ecological contexts not only enhances the relevance of the curriculum but also promotes a deeper understanding of global environmental challenges through a local lens. By fostering an appreciation for the wisdom embedded in traditional ecological knowledge, educators can inspire a new generation of environmental stewards equipped with both the critical thinking skills and the cultural insight necessary to navigate the complexities of conservation in the 21st century.

Finally, the inquiry-based ethnoecological conservation approach represents a significant advancement in environmental education, offering a dynamic and culturally sensitive method for enhancing students' critical thinking skills and environmental stewardship. The findings of this study underscore the value of integrating indigenous knowledge into educational frameworks, providing a powerful tool for empowering students to contribute meaningfully to conservation efforts. As the world grapples with the escalating challenges of environmental degradation and climate change, fostering a deep-seated understanding and respect for the intricate relationships between humans and their environment through education becomes increasingly critical. This study paves the way for future research and practice in this field, highlighting the importance of innovative, inquiry-based approaches that harness the rich diversity of ethnoecological knowledge to inspire the next generation of critical thinkers and environmental guardians.

CONCLUSION

The inquiry-based ethnoecological conservation approach investigated in this study marks a significant stride in environmental education, specifically in enhancing critical thinking skills among students. By seamlessly integrating ethnoecological knowledge with inquiry-based learning methods, the research has illuminated a path that not only augments students' ability to think critically about complex environmental issues but also deepens their connection to and appreciation for their cultural and ecological heritage. This innovative pedagogical approach has demonstrated substantial improvements in critical thinking abilities across a diverse student population, as evidenced by the quantitative and qualitative analyses presented. The findings suggest that students not only gained a more nuanced understanding of environmental conservation but also developed a stronger sense of responsibility towards sustaining their natural surroundings. This educational model, therefore, stands out as a potent mechanism for cultivating a generation of informed and motivated environmental stewards, equipped with the critical thinking prowess necessary to tackle the pressing ecological challenges of our time.

Moreover, the research highlights the universal applicability and effectiveness of this approach in promoting a holistic understanding of environmental stewardship, transcending traditional learning boundaries to incorporate indigenous knowledge systems. Such integration proves vital in fostering a comprehensive educational experience that respects and

utilizes the rich tapestry of cultural wisdom in conservation efforts. The study's outcomes reinforce the crucial role of inquiry-based learning in environmental education, underpinning the necessity for educational frameworks to embrace and integrate ethnoecological perspectives. This not only enriches the curriculum but also empowers students, enabling them to contribute meaningfully to local and global conservation endeavors. As we move forward, the inquiry-based ethnoecological conservation approach offers a promising blueprint for enhancing educational practices, advocating for a more inclusive, reflective, and dynamic learning environment that nurtures critical thinking and fosters a deep-seated connection with the environment.

LIMITATION

This study, while comprehensive in its design and execution, is not without limitations. A primary constraint is the relatively small sample size and the geographic specificity of the participant pool, which may impact the generalizability of the findings to wider educational contexts. The research was conducted within a specific cultural and ecological setting, which, while invaluable for in-depth exploration of ethnoecological integration, might limit the applicability of the conclusions across diverse educational environments with varying cultural and ecological characteristics. Additionally, the study's reliance on self-reported data from students could introduce bias, as perceptions of learning and engagement might not fully capture the depth of critical thinking skill development. Furthermore, the intervention period, spanning two months, provides a snapshot of the potential impacts of the inquiry-based ethnoecological approach but may not fully account for long-term retention of critical thinking skills or the sustained engagement in environmental stewardship. These limitations underscore the need for further research involving broader and more varied populations, as well as longitudinal studies to assess the enduring effects of this pedagogical approach on students' critical thinking abilities and their commitment to conservation efforts.

RECOMMENDATION

Based on the findings of this study, it is recommended that future research should extend beyond the current limitations by incorporating a larger, more diverse sample size and exploring the implementation of the inquiry-based ethnoecological conservation approach in varied cultural and ecological contexts. Such research would provide deeper insights into the universality and adaptability of this pedagogical method, offering a richer understanding of its impact on critical thinking skills across different educational settings. Additionally, longitudinal studies are essential to evaluate the long-term effects of this approach on students' critical thinking development and their sustained interest and involvement in environmental conservation. It is also suggested that subsequent research endeavors should explore the integration of technology and digital learning tools within the inquiry-based ethnoecological framework to enhance accessibility and engagement among students. By addressing these recommendations, future studies can build upon the foundational insights provided by this research, further advancing the field of environmental education and

contributing to the development of well-informed, critically thinking, and environmentally responsible citizens.

Author Contributions

The authors have sufficiently contributed to the study, and have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Acknowledgment

Special thanks go to the students who participated enthusiastically in the intervention, and to our colleagues for their insightful feedback and encouragement throughout the research process.

Conflict of interests

The authors declare no conflict of interest.

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