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RESEARCH ARTICLE

Teaching indigenous science through culturally responsive pedagogy: Shaping environmental perception and cultural resilience in science education

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ABSTRACT

Integrating Indigenous science in higher education plays a vital role in shaping students' environmental perception—their cognitive, emotional, and cultural understanding of the natural world—while also fostering cultural resilience and contextualized scientific literacy. This study investigates the pedagogical practices of tertiary science teachers (TSTs) in the Philippines as they implement culturally responsive approaches to teach Indigenous science. Employing a descriptive case study design, the research draws on semi-structured interviews with seven Filipino TSTs, analyzed using the Colaizzi method. The findings reveal that teachers utilize multimodal representations, hands-on and land-based activities, community involvement, and curricular integration to foster meaningful learning experiences. These strategies facilitate deeper student engagement with local ecologies and cultural heritage, enhancing their perceptual, emotional, and behavioral connection to the environment. Nonetheless, educators face systemic challenges including limited institutional support, insufficient curriculum content on Indigenous science, and gaps in pedagogical training. Despite these barriers, participants express strong advocacy for inclusive education and highlight Indigenous science as a transformative tool for cultivating environmental values and pro-environmental behavior. The study calls for structural reforms in curriculum development, sustained educator training, and collaborative partnerships with Indigenous communities to support culturally grounded science education that enriches environmental perception.

Keywords: science education; indigenous science; pedagogical practices; culturally responsive pedagogy; environmental perception

1. Introduction

In a world facing climate change, biodiversity loss, and cultural homogenization, Indigenous science emerges as a vital resource for sustainable development, blending environmental stewardship with cultural heritage. Indigenous science refers to the scientifically relevant knowledge, practices and activities of indigenous cultures. It provides valuable contexts for understanding how sociocultural values and environmental principles interact within society[1]. Grounded in morality, mutualism, respect, and interconnectedness, Indigenous science reflects the cultural distinctiveness of particular groups, with the aim of preserving these ways of living for future generations[2]. Its holistic and relational worldview emphasizes

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the interconnected equilibrium of all living systems, offering an alternative paradigm to Western scientific perspectives [2].

The integration of Indigenous science in the teaching-learning process does not only help students to grasp scientific concepts but also serves as an essential step toward fostering scientific literacy[3] and shapes environmental perception and cultural resilience. Such integration bridges the gap between formal education and real-world societal challenges, creating meaningful learning experiences[3-4]. Globally, organizations like UNESCO recognize Indigenous science as critical to sustainable development and educational innovation. Despite this recognition, incorporating Indigenous science into formal education systems, particularly at the tertiary level, remains a challenge in many countries, including the Philippines.

In the Philippines, the importance of Indigenous Knowledge Systems and Practices (IKSPs) is legally recognized under Republic Act 8371, also known as the Indigenous Peoples' Rights Act (IPRA) of 1997. IPRA defined IKSPs as "*a unique body of knowledge evolved through time embodying patterns of relationships between and among peoples, their lands and resource environment, which have allowed indigenous peoples to survive and thrive within their given socio-cultural and biophysical conditions*" [5]. This legislation underscores IKSPs' positive impact on environmental preservation and their potential to drive innovation and generate new ideas [6]. Policies like the Department of Education (DepEd) Order No. 62, s. 2011, which adopts the National Indigenous Peoples (IP) Education Policy Framework [7], and DepEd Order No. 32, s. 2015, which integrates indigenous knowledge into the Indigenous Peoples Education Curriculum Framework [8], further affirm the growing acknowledgment of Indigenous science's role in enriching science education. Despite these supportive policies, significant challenges remain in effectively translating them into classroom practice, especially at the tertiary level.

Historically, Indigenous knowledge and science have been marginalized in science curricula [9]. Nevertheless, integrating indigenous knowledge into school science remains a powerful strategy for revitalizing its educational significance [10]. For this to succeed, educators should understand how classroom science and indigenous knowledge can complement one another [11]. For tertiary science teachers (TSTs) in the Philippines, the introduction of the interdisciplinary course Science, Technology, and Society (STS) under the New General Education Curriculum [12] marks a significant step toward aligning science with cultural and societal contexts. However, the practical challenges faced by TSTs in reconciling indigenous and modern scientific knowledge in classrooms remain underexplored.

While studies have examined indigenous knowledge integration in school science curricula, limited attention has been given to tertiary-level implementation. Existing studies [13-15] have primarily focused in policy frameworks and professional development programs, with less emphasis on classroom-level realities. The pedagogical strategies that TSTs use to bridge indigenous and modern scientific knowledge, and how these strategies are shaped by cultural and institutional contexts, require further investigation.

Furthermore, studies [16-17] have only focused on the integrating indigenous knowledge in the science curriculum, and it seems that the pedagogical challenges in carrying out classroom activities in Indigenous science to craft necessary interventions and tools to be implemented and developed respectively have been moderately explored. These gaps point to the need for a more nuanced understanding of the practices and challenges that TSTs encounter when teaching Indigenous science concepts, particularly in the unique cultural and institutional contexts of the Philippines. Furthermore, studies often overlook how teachers make sense of and respond to these challenges, particularly within the diverse cultural and institutional contexts of the Philippines.

In the context of this research, "environment" is understood through the multidimensional lens of environmental psychology [18], which includes natural, social, physical, and psychological domains. The natural environment refers to the ecological settings and landscapes from which indigenous knowledge systems emerge such as forests, rivers, agricultural lands, and biodiversity-rich areas that are central to traditional ecological knowledge (TEK). The social environment encompasses the classroom culture, community relationships, and educational structures in which teaching and learning occur. This includes the norms, values, and interactions that shape how Indigenous science is received and practiced by both teachers and learners. The physical environment includes the built spaces of the educational institutions where science is taught, as well as the community locations where land-based learning happens. Lastly, the psychological environment refers to the perceptual and emotional responses of teachers and students as they interact with cultural and ecological content—shaping attitudes, identity, and pro-environmental behaviors [18]. Recognizing these distinct but overlapping domains enables a richer analysis of how CRP influences environmental perception and behavior.

Environmental perception, in the context of this study, extends beyond cultural appreciation to encompass the cognitive and emotional processes by which individuals internalize and respond to their physical and natural surroundings [18-19]. On the other hand, it also draws on the concept of cultural resilience, defined as the ability of individuals and communities to sustain and adapt their cultural identity, practices, and knowledge systems in response to external pressures such as colonial education frameworks [20], particularly when indigenous knowledge is meaningfully validated and integrated into formal curricula.

Anchored in Ladson-Billings' principles of Culturally Relevant Pedagogy (CRP), this study explored how tertiary science teachers navigate the interplay between indigenous knowledge and modern science. This theoretical lens not only provides a foundation for understanding teaching practices but also highlights the transformative potential of culturally responsive science education. CRP emphasizes three key principles: (1) fostering student learning and academic success, (2) developing students' cultural competence to enhance their social and ethnic identities, and (3) cultivating students' critical consciousness to recognize and address societal inequities. Moreover, CRP emphasizes reciprocal teacher-student exchanges to acknowledge and integrate their cultural backgrounds and knowledge [21]. While this study is grounded in Ladson-Billings' CRP, it also draws on the more field-specific framework of Culturally Relevant Science Pedagogy (CRSP). CRSP is an extension of CRP that explicitly connects scientific content with students' lived experiences, cultural knowledge, and social realities. CRSP promotes stronger student identities, enhances critical thinking, improves learning outcomes, and encourages engagement in science-related careers [22]. While CRP emphasizes fostering academic success, cultural competence, and critical consciousness, CRSP adds a focus on epistemological inclusion—validating non-Western ways of knowing and contextualizing scientific inquiry. This distinction is critical in science education, where Indigenous knowledge systems often diverge methodologically and philosophically from dominant scientific paradigms.

In this study, environmental perception is understood from the perspective of environmental psychology, referring to how individuals experience, interpret, and emotionally relate to their natural surroundings [19]. While this study does not directly measure students' environmental perception, it explores how the pedagogical practices of tertiary science teachers are designed to cultivate such perception through culturally rooted science education. CRP is positioned as a mediator of this perceptual transformation, shaping learners' psychological connection to place and nature.

By uncovering the pedagogical practices and challenges of TSTs, this study contributed actionable insights for developing culturally responsive interventions. These findings inform future efforts to harmonize

indigenous knowledge with modern science education. Accordingly, three research questions were examined in this study: (1) How do TSTs teach Indigenous science concepts?; (2) What challenges do TSTs encounter in teaching these concepts?; and (3) How do TSTs make sense of these challenges?

While this study frames environmental perception and cultural resilience as key constructs, it is important to note that data collection did not include direct student input. Thus, any claims regarding changes in learner perception or identity are based on teacher narratives and theoretical alignment with environmental psychology literature. These interpretations, while grounded in well-established frameworks, remain speculative and call for future empirical validation.

2. Research method

2.1. Research design

This qualitative study employed a descriptive case study to explore and develop an in-depth description of the practices of TSTs in teaching Indigenous science concepts. Case studies allow for the depiction of multiple components and how they interact in real contexts, they may be used for a number of purposes in educational research [23]. Specifically, this study adopted Stake's approach to case study which emphasizes qualitative methods rooted in constructivist and interpretivist traditions [24]. Through analysis of the data from multiple sources of information, in-depth understanding is provided through themes and issues identified by the researcher. Aside from the interviews with the key informants, some relevant documents provided by the participants were evaluated to provide a better and more in-depth description of each case.

2.2. Participants and sampling

The study included seven TSTs purposely selected from one state university in the Philippines. The inclusion criteria included (1) with at least three years teaching experience in the higher education, (2) at least a Master's degree holder with specialization in Science Education, and (3) currently teaching or had taught Science, Technology, and Society (STS) and other Science courses in the university setting. They were asked to participate in this study and willingly agreed to partake in this endeavor as evidenced by their signed informed consent document.

2.3. Data collection

In collecting relevant data for the study, semi-structured interview questions were prepared which were asked to the participants either face-to-face or via virtual conference platforms [25], and/or through electronic open-ended survey questionnaires depending on their preference. The semi-structured interview is advantageous for qualitative research because it enables researchers to obtain substantial data and supporting evidence from participants while taking the topic of the study into account [26]. A semi-structured interview is a qualitative research method that blends a predetermined set of open-ended questions with the flexibility to explore specific responses in greater depth. It is flexible and adaptable [26] as it allows the researchers to make follow-up questions for clarification.

These interview questions which aimed to extract the practices and challenges of the participants in the teaching of Indigenous science concepts have been content validated by three experts in science education and qualitative research. Moreover, with the participants' permission, the interviews were recorded; they were also duly transcribed and stored. Although the interview questions did not include items directly referencing environmental perception, participants often described teaching strategies intended to deepen students' environmental awareness, cultural identity, and connection to local ecologies—concepts aligned with environmental perception.

Table 1 shows the validated open-ended interview questions based on the research questions:

Table 1. Validated interview guide.

Research Questions	Interview Questions
How do TSTs teach Indigenous science concepts?	a. What is your understanding of Indigenous science/knowledge? b. Where do you get/learn ideas and concepts of indigenous knowledge or Indigenous science? c. Do you think learning Indigenous science concepts is important for college students? If yes, how this affects your teaching of indigenous science concepts? d. How do you teach Indigenous science concepts in your science classroom? e. What activities do you prepare in your teaching of Indigenous science concepts? f. How do you prepare these activities? What considerations and factors you look into in preparing these activities? g. How do these activities promote learning of Indigenous science concepts?
What challenges do TSTs encounter in teaching these concepts?	a. Looking back, have you experienced any challenges when it came to teaching Indigenous science concepts? b. What have been your struggles in teaching of Indigenous science concepts in your science classroom? c. What are the factors which serve as barriers to teaching and learning of Indigenous science concepts?
How do TSTs make sense of these challenges?	a. What experiences have been helpful in your teaching of Indigenous science? b. How do you address the challenges you have encountered in your teaching of Indigenous science concepts? c. What do you wish to know more about as far as teaching of Indigenous science concepts is concerned?

Further, documents such as the learning plans and syllabus were collected from the participants to further analyze their practices through document analysis. These documents were analyzed thematically to identify alignment between teachers' stated pedagogical strategies and their classroom implementation. While the documents did not introduce wholly new themes, they substantiated the authenticity and consistency of the practices described by participants.

2.4. Data analysis

The Colaizzi process [27] was used to analyze the gathered data rigorously and robustly while ensuring the credibility and reliability of the results. It started by reading the interview transcript and each participant's comments several times to obtain a basic sense of the material. Second, key phrases related to the subject of the study were highlighted. Thirdly, the importance of these crucial claims was gleaned. Following labeling in line with the study goals, the created meanings were organized into categories, clusters of themes, and subthemes. The study's findings were also integrated into a comprehensive assessment of the participant's real practices in teaching Indigenous science ideas by explaining the fundamental structure of this phenomenon. Bracketing was conducted to avoid the researcher's biases and preconceived ideas. Moreover, in order to address validity during data analysis, the study participants were asked to validate the findings by comparing the descriptive findings to their practices. The study achieved data saturation after interviewing seven participants, indicating that sufficient information and themes had been thoroughly explored.

As a science educator, the author acknowledges the potential influence of personal positionality on the interpretation of data. To mitigate this, bracketing was employed throughout data analysis, and member-checking was conducted to validate findings. The author maintained reflexive notes to continuously monitor biases, ensuring that participants' voices remained the central focus of analysis.

2.5. Ethical considerations

The author affirms that data management procedures, including data collection, storage, and analysis, were followed. Through the signed informed consent form, the participants were adequately instructed and made aware of their involvement in the study. The information gathered was treated with the utmost confidentiality, privacy, and anonymity. The participants received no payment or other financial benefits for their participation in the study.

3. Results and discussion

This section presents the key findings on the pedagogical practices and challenges encountered by TSTs in teaching Indigenous science. Drawing from participant narratives and thematic analysis, the discussion highlights culturally responsive strategies adopted by TSTs, as well as systemic and instructional barriers that influence their integration of Indigenous knowledge in science education. These insights not only illuminate current classroom practices but also underscore the need for inclusive curricula and sustained support for culturally grounded science teaching. **Table 2** below summarizes the study's key themes across three major constructs: pedagogical practices, challenges, and teachers' sense-making responses.

Table 2. Summary of key themes.

Constructs	Themes
Pedagogical Practices	*- Teaching Through Multimodal Representation*
	- Teaching Through Varied Learning Activities
	- Teaching Through Content Integration
	- Teaching Through Community Engagement
Challenges	*- Lack of Learning Resources*
	- Lack of Representation and Inclusion in the Curriculum
	- Limited Understanding and Appreciation of Indigenous Knowledge
	- Lack of Pedagogical Competence
Sense-making	*- Reflective Practice and Adaptation*
	- Consultation and Collaboration with Indigenous Communities
	- Commitment to Professional Growth and Cultural Learning

3.1. Tertiary science teacher's pedagogical practices

The following themes highlight the culturally responsive pedagogical practices of TSTs in teaching Indigenous science. These themes reveal how TSTs employ diverse strategies, from multimodal representations and varied activities to integrated content and community engagement, to create inclusive, meaningful, and contextually grounded science learning experiences.

Theme 1. Teaching Through Multimodal Representation

Participants highlighted the importance of utilizing diverse modes of representation [28], including written and spoken language, visuals, hand gestures, and tangible models, to aid in the understanding of Indigenous science concepts. Moreover, TSTs use varied representations to explain scientific ideas besides textbooks that contain images, writing, and other kinds of representation to help students make sense of and learn the concepts [29]. One teacher responded: "Through asking their prior knowledge, giving example through multimodal representation and relating their experiences which are considered Indigenous science."

The use of teaching resources, such as textbooks with images, text, and other kinds of representation, was highlighted as a way for TSTs to aid their students in making sense of Indigenous science concepts. The tools utilized by the participants in teaching Indigenous science concepts in their science classes include PowerPoint presentations, simulations, books, texts, and visuals. While these resources can be valuable, there is a need to critically evaluate their content and cultural relevance. For instance, textbooks and visual aids should not perpetuate stereotypes or present a limited view of Indigenous science concepts. Instead, they should reflect

diverse perspectives and promote cultural authenticity and respect. These multimodal strategies, when rooted in culturally familiar narratives and visuals, can help students emotionally connect with scientific ideas, reinforcing place-based awareness and shaping their environmental perception through cognitive-affective engagement.

Aligning with the first precept of CRP, which prioritizes student learning and academic success, this practice of incorporating diverse modes of representation is foundational. However, its successful implementation goes beyond mere incorporating diverse modes of representation; it demands a thorough grasp of students' cultural contexts, experiences, and knowledge frameworks. Achieving meaningful engagement and learning outcomes requires continual reflection and adaptation of teaching strategies to cater effectively to diverse student needs.

Theme 2. Teaching Through Varied Learning Activities

The use of various forms of interaction, hands-on activities, and science applications in the classroom was associated with higher levels of student enthusiasm, satisfaction, and future orientation toward science [30]. These varied activities that required the most engagement and motivation were those that went beyond the confines of a single course and required more independent, self-directed learning, and collaboration with peers. Thus, participants emphasized that teaching through varied learning activities help students learn the concepts of Indigenous science easily. These activities include participation in traditional hands-on activities such as basket weaving, knapping, or pottery making, which not only provide firsthand cultural experiences but also foster a deeper connection between indigenous people and their environment. Such engagements help shape students' environmental perception by allowing them to experience and interpret natural processes and ecological relationships through a cultural lens. These practices align with the ideas of [31] that hands-on activities may help students to understand science topics better by helping them to relate abstract concepts to real-world experiences.

Moreover, the use of storytelling activities was also evident as useful for TSTs in teaching Indigenous science as according to one participant, "hearing traditional stories passed down through generations helps in understanding the cultural context of Indigenous scientific concepts." The use of storytelling in teaching Indigenous science is a worthy strategy [32], since indigenous stories are rooted in the cultural aspect of the place and characterized by the land, language, and people, storytelling reconnects with land-based learning. In addition, role-playing and group discussions were also used by the participants in teaching Indigenous science concepts, for instance in biodiversity conservation.

Students' emotional engagement with Indigenous science may enhance ecological identity, a psychological construct associated with increased environmental concern and sustainable action [33]. This underscores how culturally embedded experiences contribute not only to content learning but also to affective and behavioral outcomes central to environmental psychology.

The practices of the TSTs suggest the provision of CRP in developing students' cultural competence to promote positive ethnic and social identity. However, TSTs must engage in thorough reflection on the potential challenges and limitations associated with these practices, such as ensuring the authenticity and accuracy of indigenous stories and cultural representations through consultation with indigenous communities. This is essential for creating inclusive and respectful learning environments that honor diverse cultural perspectives. The integration of indigenous knowledge into science teaching not only affirms cultural identity but may also reinforce pro-environmental behaviors through modeling and experiential learning, aligning with Bandura's social learning theory and principles of behavioral reinforcement in environmental psychology. These

culturally immersive and land-based strategies are likely to foster students' environmental perception by strengthening their experiential and emotional connection to the natural world.

While these observations are supported by environmental psychology literature, it is important to acknowledge that this study did not collect direct learner data. Therefore, the influence of CRP on students' environmental perception remains a theoretical extrapolation based on teacher accounts and conceptual frameworks.

Theme 3. Teaching Through Content Integration

TSTs recognize the significance of content integration, particularly in integrating Indigenous science concepts into the curriculum. The use of an integrated curricular approach in the classroom is justifiable for a number of reasons, including motivation, engagement, student-centered methods, and improvements in critical thinking abilities [34]. A participant shared that:

> "I first integrate indigenous knowledge by acknowledging its connection to particular contexts and by ensuring the meaningful inclusion of Indigenous content in science curricular areas." [TST 2]

This practice is a manifestation that TSTs understand the importance of Indigenous science in the curriculum and that even if Indigenous science concepts are nowhere to find in their science curriculum, they make it a point that they will be able to integrate them into the teaching-learning process. This agrees with the notion that it will be possible for science to be more meaningful, relevant, and sensitive to the needs and circumstances of the people by incorporating indigenous knowledge into the science curriculum [17]. Furthermore, the present study supports the idea that integrating Indigenous knowledge into students' STEM or science curriculum makes the programs culturally appropriate for the students [13]. Aligning with CRP principles, this practice not only enhances student learning and academic success but also fosters a culturally appropriate and inclusive learning environment.

Theme 4. Teaching Through Community Engagement

TSTs teach Indigenous science concepts through community engagement as they acknowledge the value of learning directly from indigenous communities and respecting their knowledge systems. With this, TSTs believe that cultural context and cultural assets are crucial components of equality in science education [35]. Consequently, to help their students understand the value of science, science education should be grounded in real-world applications and societal contexts [36]. Also, TSTs adhere that the socio-scientific and cultural aspects of science education must be taken into account in order to provide meaningful science education from a current perspective [37]. One TST shared that:

> "Indigenous knowledge and science are often passed down through generations within indigenous communities and can be learned through direct engagement with community members and participation in cultural practices. It is important to approach the study of indigenous knowledge with respect and sensitivity, and to consult with and gain permission from indigenous communities before conducting research or sharing information." [TST 5]

This narration coincides with the idea that introducing indigenous knowledge in the classroom can represent the various cultural origins of the students and may enhance their ability to interpret information [38]. It also plays a critical role in developing students' environmental perception, how they cognitively and emotionally understand their surroundings in ways rooted in culture and community practice. Correspondingly, it also agrees that teaching through community engagement and involvement has the influence to make science

instruction more relatable for students in schools with a variety of cultural backgrounds [39-40]. This practice aligns with the second and third precepts of CRP, focusing on developing students' cultural competence to promote positive ethnic and social identity, as well as fostering critical consciousness. This indicates that TSTs recognize the significance of community engagement in facilitating meaningful learning of Indigenous science, as it encourages students' critical awareness and their capacity to identify and analyze societal disparities.

Participants observed that when students learned in culturally significant environments, they began to form emotional bonds and new interpretations of nature's value. These pedagogical strategies not only transmitted content but reshaped how students psychologically perceived their relationship with the environment—transitioning from passive observers to emotionally invested stewards of nature. Through these community-based engagements, teachers not only contextualize science learning but also strengthen students' ties to their heritage—supporting the transmission of cultural knowledge and contributing to the development of cultural resilience.

These pedagogical strategies are more than just tools for content delivery—they serve to reaffirm Indigenous identities within academic spaces. In doing so, they support cultural resilience by helping learners maintain a strong sense of cultural belonging, even within Western-modeled science curricula.

3.2. Challenges in teaching indigenous science concepts

The following themes outline the key challenges faced by TSTs in integrating Indigenous science into their practice. These include gaps in resources, curriculum inclusion, pedagogical preparedness, and cultural appreciation—all of which highlight the urgent need for systemic support and culturally grounded teacher training to foster equity and inclusion in science education.

Theme 1. Lack of Learning Resources

Learning resources are pivotal in the learning and teaching of Indigenous science. Academic achievement and instructional resources have a very strong, favorable, and substantial relationship [41]. Nonetheless, participants have cited the lack of learning resources for Indigenous science as according to them, "there is a lack of resources and materials available to educators to teach Indigenous science concepts."

Though they have enough textbooks, it is noted that these materials rely heavily upon Western ideas of science, and integration of Indigenous science remains elusive. This is congruent to the findings of a recent study that opines that teachers rely on documented information through books that heavily rely on Western-dominated knowledge system [42]. Accordingly, it was suggested that students will perform better in school if localized, indigenous educational materials are prepared and developed [43].

The strain between the limited availability of Indigenous science learning resources and the significance of integrating indigenous knowledge into science education highlights the necessity for innovative solutions. Collaborative efforts involving educators, indigenous communities, and educational institutions can result in the development of culturally relevant learning resources that will bridge the gap between Western scientific concepts and indigenous knowledge systems. These efforts are essential for fostering a more inclusive and comprehensive approach to teaching of Indigenous science concepts.

Theme 2. Lack of Representation and Inclusion of Indigenous Science in the Curriculum

While adopting metaphors and symbols from indigenous cultures [2] can enrich curriculum development, participants highlight the existing lack of representation and inclusion of Indigenous science in the science curriculum. One participant reported that:

> "In light of indigenous knowledge, students will be able to appreciate the value of Indigenous science. Unfortunately, in the basic education curriculum, you cannot find any learning competence implying the inclusion of indigenous knowledge. Teachers are left wondering how to integrate it into their lessons." [TST 2]

The absence of explicit guidelines or frameworks for incorporating Indigenous science concepts leaves teachers to navigate this integration independently which may lead to missed opportunities for meaningful learning experiences. With this, there is a need for deliberate efforts to include Indigenous science concepts within the curriculum framework to provide science educators with clear guidelines, resources, and training to facilitate meaningful integration into the teaching-learning process.

Theme 3. Limited Understanding and Appreciation of the Value and Relevance of Indigenous Knowledge Among Educators and Students

Teachers are held responsible for the information they bring to the classroom when they collaborate with the local indigenous practices which foster a kind and reciprocal connection between educators and the community [44]. While understanding and appreciating the value of indigenous knowledge are crucial for effective teaching and learning of Indigenous science, TSTs express concerns about the limited understanding and appreciation of indigenous knowledge among educators and students. One participant mentioned:

> "It is evident that most of the science references used by Filipino learners are based on western science. I think it is high time to introduce Indigenous science so that Filipino students can appreciate it. Actually, a lot of published retrieval research is available on the internet. In fact, in the field of conservation biology, one current interest is traditional ecological knowledge and its integration into conservation programs." [TST 4]

Participants shared that colonial mentality and the belief in the supremacy of foreign knowledge present challenges which leads to the marginalization of indigenous knowledge. Despite the potential of indigenous cultures to enrich science education [45], the lack of representation and inclusion of Indigenous science in the curriculum hinders its recognition and appreciation. Addressing this issue requires a comprehensive examination of indigenous knowledge within the context of science education [46] to harness its capacity to enhance learning experiences and promote cultural diversity in science classrooms.

Theme 4. Lack of Pedagogical Competence

Students learning achievements are influenced by teachers' cultural competence and indigenous knowledge [47]. While the importance of teachers' pedagogical and professional abilities cannot be overstated, challenges arise when teachers lack the necessary pedagogical competence to effectively impart Indigenous science concepts. TSTs reported that they are challenged since they lack the pedagogical competence to impart Indigenous science concepts. A participant shared that:

> "I find it difficult how to teach indigenous knowledge/science because I have no formal training on how to correctly do it. As the teacher, I am doing trial and error to test which particular strategy works best for a particular class considering they are of diverse socio-cultural backgrounds." [TST 7]

The comments suggest that their teacher training lacked Indigenous content; TSTs reported no formal preparation in how to teach Indigenous science. With this, efforts to enhance teachers' cultural competence and provide support in teaching Indigenous science are crucial for promoting meaningful learning experiences and honoring diverse knowledge traditions within education systems. One way is through collaboration with

Indigenous community members as specialists or "cultural mentors" to support teachers in effectively teaching indigenous content and lessons in their classrooms [44].

3.3. Making sense of the challenges

Despite the constraints they encountered in teaching Indigenous science, tertiary science teachers (TSTs) demonstrated agency, creativity, and resilience in navigating these barriers. Their responses revealed not only the practical strategies they employed but also the deeper sense-making processes that guided their professional growth. The following themes illustrate how TSTs critically reflect on their experiences, collaborate with Indigenous communities, and commit to continuous learning in order to provide culturally responsive and contextually grounded science education.

Theme 1. Reflective Practice and Adaptation

Participants described how their experiences teaching Indigenous science shaped their perspectives. TSTs regarded these experiences as valuable opportunities to advance in their teaching careers, despite the challenges they encountered. This suggests that teachers used their lived classroom experiences as a basis for rethinking and improving their strategies. They began to reassess how they designed and delivered content, tailoring instruction to better suit the cultural and contextual realities of their students. This ongoing reflection allowed TSTs to become more responsive and adaptive educators, capable of navigating complex cultural terrain with growing confidence.

Theme 2. Consultation and Collaboration with Indigenous Communities

TSTs emphasized the importance of embedding Indigenous science competencies within the tertiary science curriculum. However, they acknowledged that crafting culturally grounded science courses is not straightforward. Many stressed the need for consultation and collaboration with indigenous communities to ensure that content remains authentic, respectful, and accurate. As one participant explained:

> "I would recommend consulting with experts in the field of indigenous education and actively seeking input and feedback from indigenous communities to ensure cultural sensitivity and accuracy in the material being taught." [TST 3]

This theme highlights how TSTs do not see themselves as sole authorities on Indigenous science, but rather as co-learners working alongside cultural bearers and elders. Such collaboration enriches both curriculum and pedagogy, while fostering mutual respect and trust between schools and communities.

Theme 3. Commitment for Professional Growth and Cultural Learning

In navigating these challenges, TSTs described a proactive approach to their own professional development. They learned to prioritize their pedagogical needs, consider the learning demands and pace of their students, and carefully choose resources and activities that would make Indigenous science more accessible and engaging. This speaks to their willingness to continuously improve their cultural competence.

Teachers embraced a mindset of lifelong learning, often going beyond formal training to seek out exposure to cultural traditions, local histories, and indigenous worldviews. Moreover, participants emphasized personal qualities such as creativity, patience, initiative, and cultural sensitivity as vital to overcoming instructional challenges. Many credited their evolving competence to meaningful encounters with Indigenous knowledge systems, which not only enhanced their instructional practices but deepened their appreciation of the connections among culture, science, and the environment.

4. Limitations

While this study offers valuable insights into the pedagogical practices and challenges experienced by tertiary science teachers (TSTs) in teaching Indigenous science, several limitations must be acknowledged. First, the study did not include direct data from learners. Although the findings highlight how teachers intend to shape students' environmental perception through culturally responsive strategies, this connection remains a theoretical extrapolation. No empirical data were gathered to assess learners' cognitive, emotional, or behavioral outcomes. Second, the scope was limited to a small group of TSTs from one state university in the Philippines. As such, the findings may not fully represent the experiences of educators in other cultural or institutional settings. Finally, while rich qualitative data were obtained through interviews and document analysis, longitudinal or observational data could further strengthen future research. Future studies could benefit from a mixed-methods approach that triangulates the perspectives of teachers, students, and community members to evaluate the broader impact of integrating Indigenous science into tertiary education.

5. Conclusion and implications

The findings addressed the three research questions as follows: (1) TSTs teach Indigenous science using multimodal, experiential, and culturally grounded approaches that align with CRP; (2) they face barriers including curriculum gaps, lack of training, and limited resources; and (3) they respond by reflecting on their practice, engaging communities, and adapting their strategies to promote inclusive learning. These findings illuminate how culturally responsive science teaching nurtures environmental perception and cultural resilience.

Specifically, the findings reveal that TSTs use culturally responsive strategies—including multimodal instruction, land-based learning activities, curriculum integration, and community engagement—to support inclusive science education. These approaches align with CRP principles by affirming students' cultural identities, promoting academic success, and fostering critical consciousness. While these practices vary in form, they share a common goal: to make science learning meaningful, contextually relevant, and culturally grounded. Although environmental perception was not measured directly, the data suggest that these pedagogical practices are instrumental in nurturing it. Teachers' integration of Indigenous science appears to promote emotional and cultural attachment to place, which environmental psychology identifies as a key precursor to pro-environmental behavior.

However, pedagogical challenges were seen as a burden in delivering Indigenous science lessons. The lack of learning resources underlying Indigenous science was a problem encountered by TSTs. Thus, it is recommended that localized and contextualized Indigenous science educational materials and resources will be developed and be verified by community experts. The lack of representation of Indigenous science in the curriculum and the limited understanding and appreciation of the value and relevance of Indigenous science are other challenges encountered by TSTs. They also reported for their needs for professional development programs to enhance their pedagogical competence in teaching Indigenous science concepts.

Despite these challenges, the TSTs expressed a commitment to advancing their pedagogical practices and enhancing their cultural competence. They recognize the value of incorporating indigenous perspectives into science education and emphasize the importance of collaboration with experts from indigenous communities. Moreover, their experiences highlight the transformative potential of engaging in meaningful professional growth, fostering cultural awareness, and embracing diverse teaching strategies to make science education more inclusive and relevant.

TSTs use good teaching methods aligned with CRP, but these methods are generic science-teaching techniques rather than unique Indigenous approaches. This could be attributed to the challenges they were

experiencing, for instance the lack of representation of Indigenous science in the curriculum and the limited understanding and appreciation of the value and relevance of Indigenous science.

Therefore, there is a necessity for curriculum designers, policymakers, and education researchers and science teachers to fortify the teaching-learning process by instilling Indigenous science competencies in the curriculum, introducing effective teaching strategies for Indigenous science teaching, developing an educational framework and/or models for the teaching of Indigenous science, and offering Indigenous science as in elective course.

Thus, this study contributed to environmental psychology by illustrating how culturally rooted science education can shape learners' environmental perception and identity, thereby supporting sustainable behavior through culturally embedded cognitive and affective pathways. By integrating Indigenous science into science education, CRP fosters psychological transformations that shape how learners perceive, value, and emotionally relate to their environments. These perceptual shifts are crucial for developing lasting pro-environmental behavior and should be foregrounded in future research and educational policy. At the same time, these practices cultivate cultural resilience by affirming Indigenous worldviews and enabling students to see their cultural knowledge as vital to scientific understanding and environmental stewardship.

Conflict of interest

The author declares no conflicts of interest related to any part of this article.

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