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Culturally Contextualized Simple Biotechnology Learning Through Ethnopedagogy: A Qualitative Case Study in Siem Reap, Cambodia

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Abstrak

Pembelajaran sains sering dipersepsikan membutuhkan laboratorium dan peralatan canggih, sehingga menjadi tantangan bagi sekolah dengan keterbatasan sumber daya. Penelitian ini bertujuan mengeksplorasi implementasi aktivitas pembelajaran bioteknologi sederhana yang memanfaatkan bahan tumbuhan lokal di sekolah di Siem Reap, Kamboja. Meskipun berbagai penelitian telah membahas pembelajaran bioteknologi berbasis laboratorium, masih terbatas kajian yang mengintegrasikan aktivitas bioteknologi sederhana dengan pendekatan etnopedagogi untuk mendukung pembelajaran sains yang kontekstual dan responsif terhadap budaya lokal. Penelitian ini menggunakan pendekatan studi kasus deskriptif kualitatif dengan sumber data berupa gambar hasil karya siswa, observasi kelas, dan dokumentasi visual. Dalam penelitian ditemukan bahwa siswa terlibat aktif dalam eksplorasi sains melalui kegiatan transfer pigmen bunga menggunakan bunga-bunga lokal. Karya siswa menunjukkan berbagai simbol budaya yang bermakna, seperti Angkor Wat, bunga teratai, rumah tradisional Kamboja, buah durian, dan flora lokal. Aktivitas ini mendorong kreativitas, meningkatkan keterlibatan sensorik, serta membantu siswa menghubungkan konsep sains dengan keanekaragaman hayati dan budaya setempat. Siswa menunjukkan pemahaman kontekstual terhadap sumber daya alam melalui representasi visual yang berasal dari pengalaman sehari-hari. Dapat disimpulkan bahwa aktivitas bioteknologi sederhana yang berakar pada budaya lokal dapat menjadi alternatif pembelajaran sains yang bermakna, mudah diakses, serta memperkuat kesadaran lingkungan dan identitas budaya siswa.
Kata Kunci: bioteknologi untuk anak, pendidikan dasar, etnopedagogi, studi kasus, pembelajaran berbasis kontekstual

Abstract

Science learning is often perceived as requiring laboratory facilities and sophisticated equipment, creating barriers for schools with limited educational resources. The aims of this study to explore the implementation of a simple biotechnology learning activity utilizing locally available plant materials in a school in Siem Reap, Cambodia. While previous studies have emphasized biotechnology learning through laboratory-based approaches, limited research has examined how simple biotechnology activities can be integrated with ethnopedagogical principles to promote culturally responsive science learning. This study employed a qualitative descriptive case study approach using student-generated drawings, classroom observations, and visual documentation as data sources. The findings showed that students actively engaged in scientific exploration through flower pigment transfer activities using local plant materials. Students incorporated culturally meaningful symbols, including Angkor Wat, lotus flowers, traditional Cambodian houses, durian fruit, and local floral motifs, into their artwork. The activity stimulated creativity, strengthened sensory engagement, and encouraged students to connect scientific concepts with local biodiversity and cultural heritage. Furthermore, students demonstrated contextual understanding of natural resources through artistic representations rooted in their everyday experiences. The study concludes that simple activities grounded in local culture can provide meaningful and accessible science learning while strengthening students' environmental awareness and cultural identity.
Keywords: *biotechnology for kids, basic education, ethnopedagogy, case study, contextual learning*

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INTRODUCTION

Biotechnology education plays an important role in developing scientific literacy, environmental awareness, and problem-solving skills among learners. Nevertheless, biotechnology instruction is frequently associated with laboratory-based activities that require specialized equipment, chemicals, and controlled experimental settings. Such approaches can create challenges for schools in low-resource contexts, where access to laboratory facilities and scientific materials remains limited (Ndihokubwayo, 2017). As a result, biotechnology is frequently perceived as a complex and inaccessible subject, reducing opportunities for meaningful hands-on learning experiences, particularly for children in developing countries. This issue remains relevant across many ASEAN countries, where disparities in educational resources continue to affect the quality and accessibility of science education (Tuyet et al., 2024).

To address these challenges, researchers have increasingly explored culturally responsive and locally contextualized approaches to science learning. Ethnopedagogy emphasizes the connection of local wisdom, indigenous knowledge, cultural practices, and community experiences into learning process. Through this approach, scientific concepts can be connected to students' everyday lives, making learning more meaningful and relevant (Magnaye, 2025; Smith et al., 2002). Local knowledge related to medicinal plants, natural dyes, traditional food production, fermentation, and ecological practices represents valuable educational resources that can support contextual science learning and sustainability education (Zidny et al., 2020).

Recent studies have shown the educational benefits of connecting indigenous and local knowledge into science learning. According to Smith et al., (2022) and Magnaye, (2025), ethnopedagogy encourages the incorporation of local wisdom, community knowledge, and cultural experiences into teaching and learning processes, enabling students to connect scientific concepts with their everyday lives. Similarly, Zidny et al., (2020) argued that indigenous knowledge can enrich science education by promoting sustainability awareness and contextual learning. In Indonesia, Sumarni et al., (2022) demonstrated that integrating traditional medicinal knowledge into STEM learning enhanced students' scientific understanding while strengthening appreciation for local culture. Furthermore, Ogegbo & Ramnarain, (2024), through a systematic review, reported that Indigenous Knowledge Systems (IKS) integration positively influences student participation, motivation, and science learning outcomes. Parmin & Trisnowati, (2024) further emphasized that indigenous knowledge should be systematically incorporated into science curricula to promote culturally relevant learning experiences.

Despite these advances, existing studies primarily focus on scientific literacy, sustainability of education, curriculum development, and teacher preparation. Research examining simple biotechnology learning activities that utilize locally available natural materials remains limited. Furthermore, few studies have investigated how students express cultural and environmental understanding through visual representations generated during biotechnology learning activities. This gap is particularly significant because many schools lack adequate laboratory facilities but possess abundant local natural resources that can be transformed into meaningful learning materials (Ogegbo & Ramnarain, 2024; Magnaye, 2025).

The novelty of this study lies in the integration of simple biotechnology activities, local plant materials, and ethnopedagogical principles within a non-laboratory learning environment. Unlike previous studies that focused primarily on scientific knowledge acquisition, sustainability awareness, or curriculum development (Smith et al., 2022; Zidny et al., 2020; Sumarni et al., 2022), this study explores how students construct and express cultural and environmental understanding through artistic representations generated during biotechnology-based activities. The study was conducted during a biotechnology workshop in Siem Reap, Cambodia, where students used leaves, flowers, and manual pigment transfer techniques to create visual artworks.

Accordingly, this study aims to explore how simple biotechnology learning activities facilitate contextual and culturally grounded science learning through an ethnopedagogical framework. Specifically, the study seeks to answer the following research question:

How do students represent cultural and environmental understanding through simple biotechnology learning activities using natural materials?

RESEARCH METHODOLOGY

This study employed a qualitative descriptive case study approach to explore students' responses and visual representations during a simple biotechnology workshop conducted in a school in Siem Reap, Cambodia. The case study approach was selected because the research focused on a bounded educational activity situated within a specific cultural and environmental context.

The researcher was invited by Krya Global to conduct a biotechnology workshop for members of the Science Club at Achiever International School, Siem Reap, Cambodia. Prior to the workshop, coordination regarding the learning module, activity preparation, and implementation procedures was conducted with the teacher chaperone and school representatives. During the coordination process, the researcher informed the school of the intention to document and analyze students' learning outputs for research purposes within the framework of ethnopedagogy. Permission was obtained to collect visual documentation and students' work generated during the workshop, while ensuring that all data were used solely for academic research purposes.

The participants consisted of 40 students participating in a biotechnology-based creative learning workshop at Achiever International School, for basic education, April 28, 2026, Siem Reap, Cambodia. The workshop introduced students to natural pigments and plant-based exploration using locally available leaves and flowers. The participants were selected from grade 4 elementary school to junior high school that have a high interest in biotechnology and science. They are members of the science club at school.

Students engaged in hands-on activities involving:

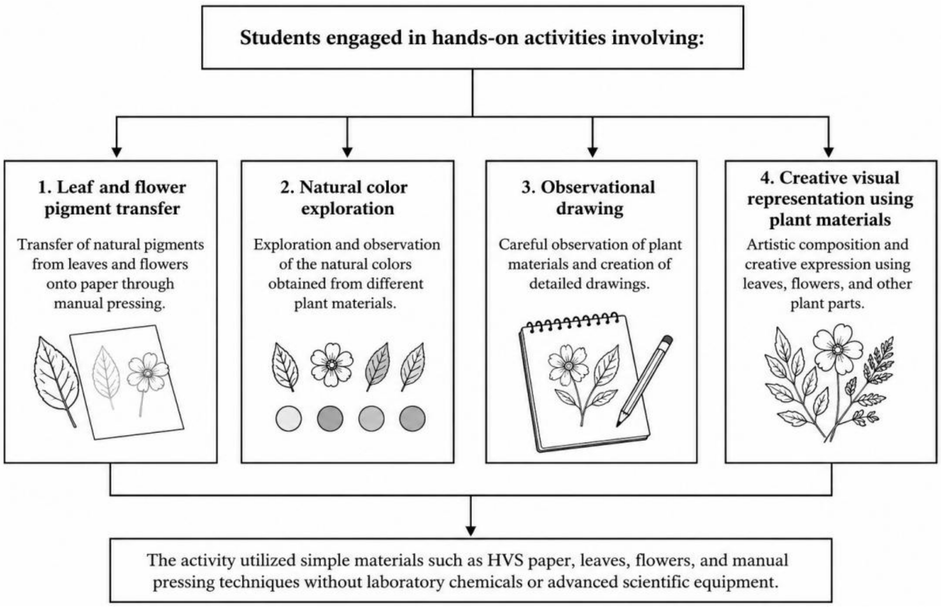

Figure 1. Flow chart activity

Data were collected from multiple sources to enable triangulation and provide a comprehensive understanding of students' cultural and environmental representations during the biotechnology learning activity. The data sources consisted of (1) student-generated drawings and visual artifacts, (2) classroom observation notes, and (3) photographic documentation of student participation and completed works.

Student-generated drawings and visual artifacts served as the primary data source. At the conclusion of the biotechnology activity, students produced artworks using natural pigments extracted from locally available leaves and flowers through a manual pigment-transfer technique. These visual products were collected and analyzed to identify recurring cultural symbols, environmental elements, and contextual representations that reflected students' understanding of their surroundings and cultural identity.

Classroom observations were conducted along the workshop to document students' engagement, interactions, discussions, and responses to the learning activities. Observation notes provided contextual information regarding how students selected materials, interpreted the task, and incorporated cultural and environmental elements into their work.

Photographic documentation was used to record the learning process, students' participation, and the final visual artifacts. These photographs served as supplementary evidence to support the interpretation of observational data and students' visual representations.

To enhance the credibility of the findings, data triangulation was conducted by comparing themes emerging from students' visual artifacts, classroom observations, and photographic documentation. Among these sources, the visual artifacts constituted the primary analytical unit because they directly reflected students' cultural and environmental meaning-making during the biotechnology learning experience.

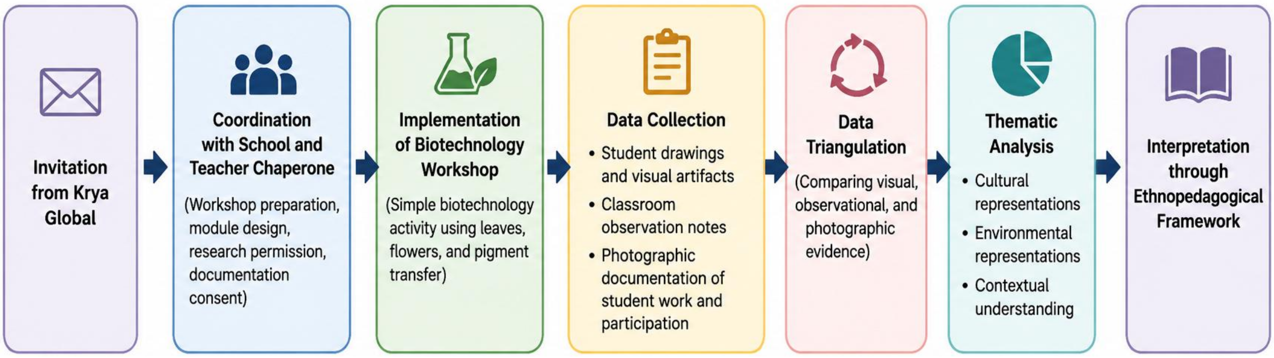

Figure 2. Research Procedures and Data Collecting Process

The data were analyzed following the procedure with thematic analysis. Student drawings and visual representations were coded based on recurring visual symbols, contextual references, and conceptual representations related to culture, biodiversity, and environmental understanding.

The coding process generated several emerging themes, including:

1. contextual connection
2. cultural identity representation
3. creativity and artistic interpretation
4. environmental familiarity
5. exploration of biological resources

RESULT AND DISCUSSION

Integration of Cultural Identity in Scientific Expression

The findings demonstrated that students consistently incorporated Cambodian cultural symbols into their visual artworks during the biotechnology activity. Various representations emerged, including Angkor Wat, traditional Cambodian houses, lotus flowers, champa flowers, and local fruits such as durian. These visual artifacts indicate that students did not perceive the activity merely as a scientific exercise but as a space for expressing their cultural identity and lived experiences. This aligns with ethnopedagogical perspectives emphasizing that knowledge construction is inseparable from learners' sociocultural realities and community contexts (Magnaye, 2025; Smith et al., 2002; Otulaja, 2017).

The workshop began by dividing students into ten groups, each consisting of four to five members. They were first invited to reflect on their childhood memories of Siem Reap, their hometown, and their national heritage. This reflective process functioned as a cultural activation phase, enabling students to connect personal memory with scientific exploration. Previous studies have shown that culturally responsive pedagogy enhances students' emotional engagement and learning motivation because it validates their identities and lived experiences (Anor et al., 2022; Tanjung et al., 2025).

Three groups selected Angkor Wat as their central visual representation, symbolizing historical continuity and national pride. The repeated appearance of this monument reflects how cultural landmarks serve as cognitive anchors in contextual learning. Similar findings were reported by Verawati & Wahyudi (2024), who found that integrating local wisdom in science learning significantly improved scientific literacy by making scientific concepts more relatable to students' cultural backgrounds. In this context, Angkor Wat functioned not only as a cultural symbol but as an epistemological bridge connecting heritage with scientific observation.

One group illustrated traditional Cambodian rural houses, demonstrating students' connection to their immediate environment. This finding supports Riggs (2005), who argued that field-based and place-based learning strengthens learners' understanding by situating scientific inquiry within familiar ecological and cultural spaces. Through this process, science becomes grounded in place-based realities rather than abstract theoretical constructs.

Similarly, lotus flowers and champa flowers repeatedly appeared in students' drawings. These plants hold deep symbolic significance in Cambodian culture, representing spirituality, beauty, and everyday environmental familiarity. The representation of these plants supports Sumarni et al., (2022), who emphasized that indigenous botanical knowledge could enrich science learning by connecting biological concepts with cultural values. Zidny et al., (2020) further argue that indigenous knowledge contributes to sustainability education by reinforcing ecological awareness through local biodiversity.

From a philosophical perspective, the interconnected appearance of architecture, plants, and landscapes reflects the Taoist understanding of harmony between humans and nature. According to Ames, (2003) and Miller, (2003), Taoist philosophy views knowledge as emerging from relational balance between environment, culture, and lived experience. In this study, students' artworks reflected this holistic interconnectedness, where scientific observation and cultural memory merged naturally.

Contextual Understanding of Biological Resources

The findings also revealed students' contextual understanding of plants as biological resources. The appearance of durian fruit in one group's artwork suggests recognition of local biodiversity as part of everyday life. Students identified plants not merely as objects of observation but as functional resources connected to food, fragrance, medicine, and aesthetic purposes. This finding reflects UNESCO's (1986) early argument that biotechnology education should be grounded in real-life applications to make scientific concepts meaningful for young learners.

One student group added written descriptions explaining the use of flowers for perfume, aromatherapy, and decoration. This demonstrates an emerging understanding of plant utility and natural product development. Such contextual awareness aligns with Sudirman et al. (2025), who found that ethnoscience-based learning helps students identify practical scientific applications within their local environments.

This practical understanding is particularly important in biotechnology education, where abstract concepts such as extraction, fermentation, and pigment transfer often require contextual simplification. Vera-Choqqueccota et al. (2025) emphasized that accessible biotechnology education should focus on practical engagement rather than dependence on advanced laboratory infrastructure. In this study, the use of simple plant pigment transfer successfully introduced biotechnology concepts in a low-cost, highly contextualized way.

The findings also reinforce Otulaja, (2017) argument that science education should adapt to local cultural contexts rather than imposing purely Western scientific frameworks. By allowing students to interpret plants through their own community knowledge, the activity positioned biological materials as culturally embedded scientific resources.

Creativity and Sensory Engagement

Students demonstrated high levels of creativity through variations in drawing composition, visual symbols, and pigment application. The use of natural pigments produced diverse textures, colors, and patterns, encouraging experimentation and multisensory engagement. This sensory dimension of learning is significant because tactile and visual experiences strengthen conceptual retention and scientific curiosity.

The freedom to choose their own symbols and materials fostered student agency and autonomy. This finding supports Seehawer & Breidlid, (2021), who argued that dialogical learning between formal scientific knowledge and indigenous knowledge systems creates richer and more inclusive educational experiences. The students' creative decisions reflected this dialogue, where scientific materials became tools for cultural storytelling.

Moreover, Shambare & Jita, (2025) emphasized that resource-constrained educational environments often require innovative and improvisational teaching approaches. The present study demonstrates that simple natural materials can effectively stimulate creativity without requiring costly laboratory equipment. This finding also supports Ndihokubwayo, (2017), who highlighted that improvisation in science learning can increase accessibility and engagement in low-resource schools.

The use of artistic representation also enhanced emotional connection to the learning process. According to Usman Ali et al. (2025), ethnoscience activities that integrate creative expression can deepen student participation by linking science to identity, imagination, and community memory. This was clearly visible in students' willingness to experiment with pigments and personalize their scientific outputs.

Tabel 1. Students' drawing analysis

Visual Element		Possible Meaning	Initial Code	Main Theme
Angkor Wat		Cultural identity and local pride	cultural landmark representation	Contextual Connection
Traditional Cambodian house		Connection to daily environment	local environmental familiarity	Contextual Connection

Visual Element		Possible Meaning	Initial Code	Main Theme
Durian fruit		Recognition of local biodiversity	local biological resources	Conceptual Understanding
Lotus flower		National symbolism and nature appreciation	symbolic plant representation	Cultural Identity
Frangipani / Champa flower		Linking plants with function and beauty	botanical-cultural association	Creativity + Contextual Connection

Ethnopedagogical Dimensions of the Activity

The workshop revealed that simple biotechnology activities can function as ethnopedagogical learning experiences when connected to local culture and environment. Rather than separating science from everyday life, the activity positioned scientific exploration within familiar cultural and ecological contexts. This supports Parmin & Trisnowati, (2024), who argued that indigenous knowledge should be systematically integrated into science curricula to create culturally relevant and meaningful educational experiences.

The use of locally available flowers and leaves also aligns with Ogegbo & Ramnarain, (2024), systematic review, which found that Indigenous Knowledge Systems integration positively affects student participation, conceptual understanding, and classroom engagement. In this study, students' active participation and meaningful visual outputs provide evidence of such engagement.

Furthermore, the activity demonstrates how biotechnology can be democratized in low-resource educational settings. Instead of relying on expensive scientific infrastructure, the workshop utilized accessible natural materials while maintaining scientific relevance. This finding supports Ndihokubwayo, (2017) and Vera-Choqqueccota et al. (2025), who emphasized that science equity can be strengthened through simplified and contextualized practical activities.

From an ethnopedagogical perspective, the integration of cultural memory, local biodiversity, and creative scientific exploration creates a holistic learning environment. Magnaye, (2025) and Smith et al. (2022) argue that culturally responsive science education strengthens learners' environmental perception, cultural resilience, and scientific identity. The findings of this study confirm this perspective, showing that students constructed scientific meaning not only through observation but also through cultural representation and ecological familiarity.

Overall, this study demonstrates that simple biotechnology activities can serve as effective entry points for contextualized science education. By integrating culture, biodiversity, and creativity, the learning process becomes more accessible, meaningful, and responsive to students lived realities. Such approaches hold strong potential for science education in resource-limited schools across Southeast Asia and other developing regions.

CONCLUSION

This study demonstrates that simple biotechnology learning activities using natural materials can support culturally contextualized science learning in low-resource educational environments. Through the integration of leaves, flowers, and natural pigments, students not only explored biological materials but also expressed cultural identity and environmental familiarity through visual representation. The emergence of local cultural symbols such as Angkor Wat, lotus flowers, traditional houses, and local plant resources suggests that ethnopedagogical approaches can strengthen students' connection between science, culture, and daily life. The findings further indicate that meaningful biotechnology education does not necessarily require sophisticated laboratory facilities, but can emerge through contextual, creative, and culturally responsive learning experiences. Future studies may further explore the long-term impact of ethnopedagogical biotechnology learning on students' scientific understanding, environmental awareness, and cultural appreciation.

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