

# Transform your class! Bridging the concepts of indigenous knowledge and biotechnology education

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**Abstract:** Biotechnology education in many contexts remains dominated by Western-oriented scientific paradigms, leading students to engage with abstract laboratory-based concepts while overlooking the rich local knowledge that forms the cultural and scientific foundations of their communities. This study explores the transformative learning experiences of high school students through the integration of Indigenous Knowledge into biotechnology education in Indonesia. The urgency of this research lies in the need to decolonize science education and make it more relevant to cultural contexts often marginalized in formal curricula. Using an ethnographic case study approach, data were collected through classroom observations, student reflections, interviews with students and community elders, and analysis of student projects focusing on the utilization of traditional nira sap in Lamongan. The participants were 36 tenth-grade students from SMAN 1 Paciran, East Java. Findings show that transformative learning occurred through students' dynamic interactions with cultural "other(s)" in history, in memory, and with intimacy. These interactions led students to challenge their taken for granted assumptions about science, culture, and identity. This article contributes to the discourse on transformative education by illuminating how local cultural knowledge can serve as a catalyst for personal and epistemological transformation in science education.

**Keywords:** biotechnology education; ethnography; indigenous knowledge; transformative learning

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## Introduction

The increasing need for relevant and culturally responsive science education demands that educators move beyond conventional knowledge transmission. In the context of biotechnology education, students are often exposed to abstract and laboratory-centered content such as genetic engineering, cloning, and recombinant DNA, which tend to alienate them from their own cultural realities (Morton *et al.*, 2023). This disconnect not only limits student engagement but also contributes to the marginalization of traditional knowledge systems that have long applied biotechnology in everyday life (Zidny & Eilks, 2020). In Indonesia, a country rich in cultural and biological diversity, many communities have developed traditional knowledge related to fermentation, agriculture, and medicine areas closely linked to biotechnology (Syahidah *et al.*, 2023). One such example is the fermentation of *nira siwalan* (sugar palm sap) into legen, cuka, and other products. Despite its scientific richness, this practice remains largely absent from formal science curricula, and worse, is sometimes viewed negatively due to its association with the production of tuak (an alcoholic beverage) (Putri *et al.*, 2025).

This research responds to such challenges by exploring how integrating Indigenous Knowledge (IK) into biotechnology education can foster students' transformative learning. Drawing from Mezirow (2003) theory, transformative learning involves a fundamental shift in students' frames of reference through critical reflection and engagement with perspectives that are different from their own. In particular, this study examines how students' engagement with "other(s)" their cultural past, their elders, and their community served as powerful agents of transformation in their understanding of science, self, and society (Aikenhead & Ogawa, 2017). Through a classroom-based, project-oriented learning experience,

students were invited to engage with local fermentation practices not merely as scientific phenomena, but as cultural heritage worth preserving and understanding (Idul & Fajardo, 2023). This approach is aligned with current trends in decolonizing science education and enriching it with ethnoscientific knowledge (Boakye-Yiadom et al., 2025). This article seeks to illustrate how such experiences led to transformative learning, not only of scientific concepts but also of personal and cultural identities. The findings contribute to the ongoing discourse on how local knowledge systems can serve as pedagogical tools for transformative and decolonizing science education.

This article argues that transformative learning occurs in the process of knowing and rebuilding the self through students' relationships with cultural other(s) including local traditions, community elders, and lived heritage. It constitutes moments of critical shift that reposition the self and student identity in a more reflexive, relational, and culturally embedded stance. This article contributes to the ongoing discourse on transformative education by illuminating how encounters with cultural other(s) through Indigenous fermentation practices and project-based engagement can serve as a catalyst for transformation in high school biotechnology education. In what follows, I first elaborate on the importance of cultural other(s) in shaping students' transformation, arguing that the self and cultural other are relative and inseparable in the transformative learning process. I then describe the methodological framework of this study, including the school context (Grade 10, SMAN 1 Paciran, Lamongan), participants, data collection, and data analysis procedures. The next sections explore three emergent moments of transformation experienced by students in their dynamic engagement with indigenous knowledge: through classroom project activities, reflective dialogues, and interviews with community elders. The discussion concludes by highlighting how cultural other(s) not only facilitated shifts in students' scientific understanding, but also enabled them to reposition themselves with greater awareness of identity, culture, and agency within both their community and the broader context of science education.

Transformative learning, as introduced by Mezirow (2000), is an adult education process that fosters profound changes in learners' frames of reference through critical reflection on previously unquestioned assumptions. This shift in perspective extends beyond cognitive dimensions to encompass affective aspects and the learners' sense of identity (Carrington & Selva, 2020). Mezirow identified that such transformation is often triggered by a "disorienting dilemma," which prompts reflection, re-evaluation of old values, and ultimately the adoption of new, more inclusive, reflective, and open perspectives toward difference (Mezirow, 2000). While the concept of self is central to this theory, the role of the "other" in facilitating transformation has not been explicitly explored in depth. In this study, "others" is understood as individuals or groups perceived as meaningfully different from the self, due to generational gaps, differing values, cultural practices, or emotional closeness. This perspective draws on a relational approach to the self, as proposed by Hermans and Gieser (2016), which argues that identity is not formed in isolation but through dialogue and relationships with the "other," whether real, remembered, or imagined.

Science education in Indonesia and many other contexts remains strongly influenced by Western scientific traditions, which often emphasize abstract, laboratory-based biotechnology concepts while marginalizing the cultural knowledge that forms the historical foundation of scientific practice. This imbalance contributes to a disconnect between students and the scientific phenomena embedded in their own environments (Kumnuanek et al., 2022). Although recent research has demonstrated the value of integrating Indigenous Knowledge (IK) to enhance relevance, engagement, and conceptual understanding across various scientific fields, biotechnology education has not yet fully adopted this perspective (Oladipupo et al., 2025). Traditional practices such as the fermentation of *nira siwalan* into *legen* and *vinegar* despite embodying core biotechnological principles remain absent or undervalued in formal curricula and are sometimes viewed negatively due to cultural stigma (Norhazimah et al., 2025; Sharma & Kumari, 2021). As a result, students seldom recognize that modern biotechnology is deeply rooted in local knowledge systems that have been practiced for generations.

While existing scholarship on IK integration has begun to explore its pedagogical benefits, limited attention has been given to how culturally grounded biotechnology learning shapes students' perspectives, identities, and critical awareness. Most studies focus on cognitive outcomes, leaving a gap in understanding the transformative dimensions of learning that emerge when students meaningfully engage with their cultural heritage (Boon, 2020; Nieminen & Ketonen, 2024). This study addresses that gap by examining how students experience transformation through encounters with traditional fermentation knowledge in their community. By highlighting processes of reflection, identity negotiation, and cultural reconnection, this research offers a novel contribution to biotechnology education demonstrating that IK is not merely supplementary content, but a powerful epistemic resource capable of reshaping students' understanding of science and their place within it (Howard & Kern, 2019; Neeganagwedgin, 2020).

In the context of science education, particularly biotechnology, engagement with the "other" is often overlooked. Intergenerational local knowledge is seldom utilized as a learning resource, despite the prevalence of traditional biotechnology practices within communities (Maijala, 2023). By encouraging students to interact directly with local knowledge sources such as parents, village elders, and

practitioners of *legen* fermentation this study positions the “other” as a vital element in transformative learning (Li & Costa, 2022). This article examines how three forms of connection with the “other” namely, otherness in history, otherness in memory, and otherness in intimacy facilitate students’ transformation of perspectives on science and their cultural identity. These three forms not only act as catalysts for reflection but also serve as bridges between formal learning experiences and students’ socio-cultural contexts (Wu, 2024).

## Method

This study employed a qualitative ethnographic approach supported by experiential learning activities to investigate students’ transformative engagement with indigenous biotechnology knowledge in Lamongan, East Java. The research was conducted at SMAN 1 Paciran with 36 tenth-grade science students, complemented by biology teachers, parents, and local siwalan-sap practitioners who served as cultural informants. Prior to implementation, the researcher coordinated with school authorities, secured informed consent, and prepared all research instruments. Students received orientation on experiential learning procedures and basic interviewing techniques to ensure they could interact ethically and effectively with community members. Experiential activities aligned with Kolb’s model, beginning with concrete experiences in which students visited family members or local practitioners to observe siwalan-sap fermentation and conduct interviews. Students then engaged in reflective observation by writing journals describing their experiences and the personal or conceptual tensions that emerged during field encounters. These reflections were followed by abstract conceptualization through classroom discussions that connected local fermentation techniques with scientific concepts such as microbial activity, fermentation mechanisms, and environmental factors influencing product quality. Finally, students synthesized their experiential learning into short analytical reports that integrated cultural narratives with biotechnology principles.

Data were collected from February to May 2025 using three instruments: an observation sheet containing 12 items to document student engagement and interactions during field activities; a semi-structured interview guide consisting of 10 items used to explore traditional fermentation knowledge and students’ shifting perspectives; and five reflective journal prompts designed to elicit students’ reflections on assumptions, emotions, and conceptual change. Additional data sources included photographs, field notes, interview recordings, and student analytical reports. The researcher participated in field visits, documented interactions, and facilitated classroom reflections. All data were analyzed thematically following Braun and Clarke (2013) procedures involving data familiarization, coding, theme development, and refinement. Three themes emerged from the analysis, describing transformative encounters with cultural “others” through history, memory, and intimacy. Credibility was ensured through triangulation of techniques and data sources, member checking with selected students and practitioners, and maintenance of an audit trail. All participants were anonymized, and the study adhered to institutional ethical standards.

## Results and Discussion

The findings of this study confirm that experiential learning approach integrating indigenous knowledge (IK) can serve as a powerful space for transformative learning to occur. Students’ experiences interacting with the other whether in the form of history, memory, or intimacy demonstrate that transformation does not simply happen through exposure to new concepts but is more deeply driven by emotional, cultural, and social engagement that triggers critical reflection on the self and environment. This dynamic process is illustrated in Figure 1, which summarizes how IK enters project-experimental learning activities and subsequently activates three layers of transformative engagement. As shown in the Figure 1, traditional fermentation knowledge serves as the initial cultural stimulus, which is then deepened through project experiences that connect students with ancestral practices (history), childhood and family memories (memory), and intimate relationships with parents or elders (intimacy). These interconnected pathways collectively contribute to a shift in students’ scientific identity, demonstrating that biotechnology learning becomes more meaningful when rooted in their cultural heritage.

### The other in history: Reacquainting with traditional biotechnology as a forgotten heritage

The other in history opens a space for students to reconstruct the relationship between science and local culture. This supports the findings of Zidny and Eilks (2020) that integrating local knowledge into science education not only enhances conceptual understanding but also strengthens students’ scientific identity. In this context, science is no longer seen as foreign knowledge but as something that grows from one’s own cultural roots. This is important in the multicultural context of Indonesian education, where many students feel alienated by science materials that are too “global” and abstract (Neeganagwedgin, 2020).

A critical moment occurred when students studied the fermentation process of siwalan palm sap into legen and vinegar as part of their class project. During group discussions, some students initially viewed the process as "unhygienic," "unscientific," or even "rustic." This narrative reflects a modernist viewpoint that often positions traditional practices as inferior to laboratory technology. However, after interviewing local sap farmers and witnessing tapping and fermentation techniques firsthand, some students showed a shift in perspective. Student A noted in their journal:

*"Initially, I thought fermentation had to be done in a lab with advanced equipment. But seeing the traditional method, it turns out it can produce natural, healthy, and durable products. I realized our ancestors understood biotechnology long before it was called that."*

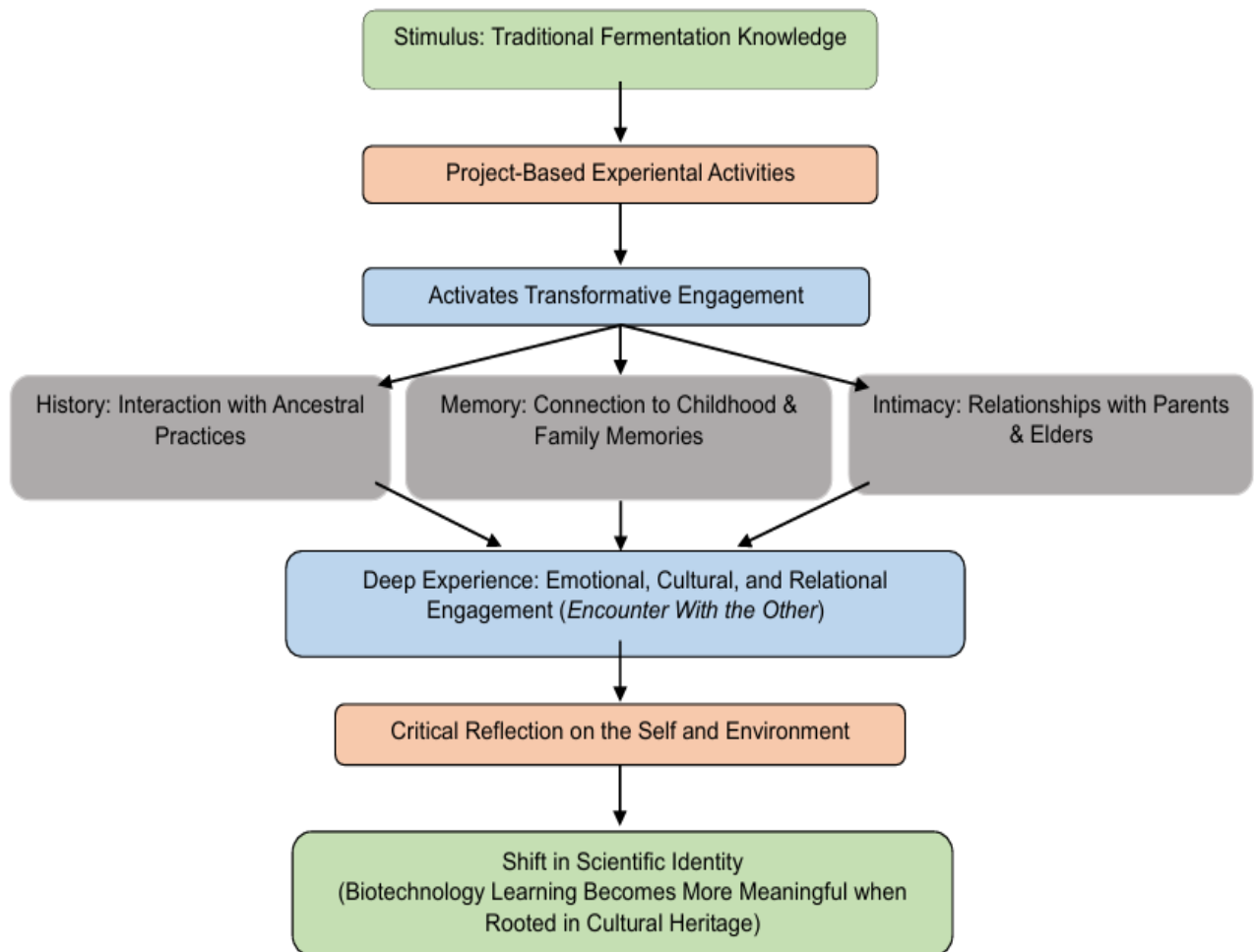


Figure 1. Transformative learning flow through indigenous knowledge-biotechnology

The discussion evolved as the teacher connected students' knowledge with literature about fermenting microorganisms. At this point, students began to understand that what they called "unscientific" was actually a form of knowledge not yet expressed in academic language. This process shows that introducing the other in history in this case, ancestors and their biotechnological practices can challenge taken-for-granted perspectives and open space for reconciliation between science and culture. The moment when students learned about the fermentation process of siwalan palm sap, initially viewed by some as "unscientific" and "old-fashioned," reflects the dominance of Western epistemology in science education, which often marginalizes local knowledge (Mello et al., 2024; Zidny & Eilks, 2020). However, direct involvement in fermentation practice and interaction with local practitioners transformed students' views on the tradition. In reflective journals, several students began to realize that traditional techniques inherently contain the fundamental principles of modern biotechnology, such as microorganism control and environmental regulation. This transformation shows that engagement with the other in history opens a space for understanding epistemological plurality in science, as emphasized by the multiscience approach (Photo & McKnight, 2024). Furthermore, previous studies demonstrate that introducing traditional practices can encourage a shift in students' views of science from being universal to a

contextual knowledge system (Bang & Medin, 2010). Thus, this direct experience breaks down the assumption that science is only valid when conducted in a laboratory and opens recognition for scientific truths embedded within one's own culture.

### The other in memory: Challenging perceptions of parents

The other in memory reveals how family experiences, previously considered irrelevant, can actually serve as valid epistemic sources. This transformation aligns with the framework of critical family pedagogy (Mezirow, 2003), which emphasizes that family experiences can enrich academic understanding and build bridges between home and school. Furthermore, this experience activates students' epistemic agency the awareness that they can independently determine knowledge authority in their lives (Li & Costa, 2022). Transformation also occurred when students were asked to write reflections about their childhood experiences related to local fermented products. One student wrote about his father, who works as a siwalan vinegar maker. He admitted that he had felt ashamed of his father's work, considering it "unmodern." However, throughout the project, he began to see that his father possessed scientific expertise without an academic degree. In an interview, Student B said:

*"I just realized that my dad really understands temperature, timing, and techniques that even my teacher said are basic biotechnology principles. I feel guilty for being ashamed to introduce his work before."*

This reflection shows how the other in memory the figure of parents previously regarded as ordinary can spark transformation in perspectives about who deserves to be called "knowledgeable in science." In this case, family experience becomes a source of learning, not merely irrelevant background. Students not only learned fermentation concepts but also underwent identity transformation as children of a "local expert." The second transformation emerged through reflection on family experience, where some students experienced a shift in meaning after realizing that their parents possessed technical skills and scientific knowledge that had been unrecognized in the formal education system. This experience aligns with Chen et al. (2020) on critical family pedagogy, recognizing family experiences as learning sources that can enhance self-esteem and strengthen students' scientific identity from marginalized communities. Through this experience, students not only began to see that their families hold valuable knowledge but also started to critique the boundaries of authority in education systems regarding who is considered "knowledgeable" and what is considered "science." From Mezirow (2000) perspective, this moment represents a disorienting dilemma that encourages students to critically reassess the values they have accepted. This reflective process fosters epistemic agency the awareness that they have the right to independently assess the validity of knowledge (Bang & Vossoughi, 2016).

### The other in intimacy: Reinterpreting relationships with parents and tradition

The other in intimacy shows that transformative learning is inseparable from emotional relationships and personal values carried by students (Chen et al., 2020). When students find meaning in experiences with their grandfathers, for example, learning becomes not only a cognitive event but also relational and spiritual. This supports (Wu, 2024) view that meaningful education always involves deep affection and relational aspects, especially within collective societies like Indonesia. The most touching transformation occurred when students engaged in interviews with close family members, particularly grandfathers still involved in processing siwalan-derived products (Monterrubio-Solís et al., 2023). One student expressed in a reflective journal feeling moved when his grandpa explained in detail the storage process of legen using bamboo and banana leaves, as well as the small rituals performed before tapping. Student C wrote:

*"I used to think grandpa was just an old-fashioned person who didn't understand technology. But now I realize he has knowledge that isn't taught in school but is very valuable."*

In the final project discussion, the student said he not only learned biotechnology but also rediscovered a deep connection with his family. He called this experience a "moment of awareness" that knowledge does not always come from teachers but also from those closest to us. The other in intimacy in this case, the grandpa herself became a catalyst for transformation not only academically but also personally and emotionally (Carter & Nicolaidis, 2023). The most emotional transformation occurred when students directly interacted with family members previously considered "ordinary" or "irrelevant to science." For example, students experienced transformation after witnessing how their grandfather applied fermentation conservation techniques while conveying life philosophies related to nature and hard work. Taylor (2007) study shows that affective experiences and intergenerational interactions can lead to relational transformation an identity change arising from meaningful relationships.

In this context, the presence of the other in intimacy acts as a mirror enabling students to reconsider themselves through the perspective of their closest relatives. Moreover, this experience deconstructs the stereotype that science is rigid, rational, and separate from values. Through such interactions, students realize that local knowledge contains spiritual, ethical, and ecological aspects rarely discussed in biology lessons, supporting Wu (2024) argument that inclusive scientific knowledge should encompass

community social and cultural values. The implications of this study are important for developing science curricula and pedagogy. Science teachers need to be empowered to view students not merely as rational individuals but as social and cultural beings carrying rich life experiences (Photo & McKnight, 2024). Transformative, project-based, and contextual learning approaches can bridge modern science and local knowledge, between schools and communities, and between theory and life (Mello et al., 2024). This study demonstrates that integrating IK into biotechnology learning has meaningful implications for curriculum design, classroom practice, and school-community partnerships. Embedding local fermentation practices helps reposition science as knowledge rooted in students' own cultural contexts rather than solely Western frameworks. For teachers, the findings highlight the importance of using students' memories, family experiences, and emotional connections as legitimate learning resources. Project-based and ethnographic approaches can deepen engagement and support transformative learning, especially when schools collaborate with local practitioners and families. Overall, IK integration strengthens scientific understanding while fostering cultural identity and relevance in science education. This study is limited by its focus on a single cultural setting, which restricts generalization to other regions without similar traditions. The qualitative nature of data relying on observations, interviews, and reflections may involve subjective interpretations. Some visual documentation could not be collected due to privacy concerns, and the relatively short research duration limits insight into long-term transformation among students. Moreover, the absence of quantitative measures prevents statistical validation of the findings. Future studies should consider mixed-method approaches and broader contexts to strengthen the evidence base.

## Conclusion

This study demonstrates that integrating indigenous knowledge into biotechnology education through a project-experiential learning approach can create transformative learning experiences for students. Three forms of engagement with the "other" in history, memory, and intimacy serve as crucial triggers in the process of reflection and reconceptualization of students' scientific identities. Beyond merely understanding fermentation as a scientific process, students undergo a shift in how they perceive themselves, their families, and their communities. They begin to appreciate that science is not solely confined to laboratories but also belongs to gardens, kitchens, and family traditions. Thus, culturally grounded science learning not only enriches cognitive insight but also strengthens students' identity roots and social awareness. This study recommends that the Indonesian science curriculum provide broader space for incorporating local knowledge into learning and train teachers to use ethnographic approaches as a means to build closeness between students and their cultural contexts. Transforming the classroom into a dialogue space between science and culture is an important step toward a more humanistic, inclusive, and meaningful education.

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## Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

## Author Contributions

**I. N. Sari:** conducting the research, collecting data, and writing original article; **S. Zubaidah;** **S. Mahanal,** and **H. Suwono:** supervising the research, revision, and advisor.

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