

Engagement of Indigenous Peoples Education Teachers in a Culturebased Professional Learning Community for Biology Teaching

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ABSTRACT

Teacher engagement is essential to advancing culturally responsive science education in Indigenous Peoples Education (IPEd) contexts. This study examined IPEd teachers' engagement in a culture-based Professional Learning Community (PLC) for biology teaching using a sequential explanatory mixed-methods design. Quantitative data were gathered through engagement surveys and participation records to assess teachers' affective, behavioral, and cognitive engagement during the PLC. These findings were further explained through qualitative data from focus group discussions, reflective journals, and collaborative outputs. The PLC brought together teachers, researchers, and Indigenous community members to co-develop biology learning resources integrating Indigenous Knowledge Systems and Practices (IKSP). Quantitative results showed consistently high engagement across all dimensions. Qualitative findings revealed increased teacher confidence in integrating IKSP, strengthened professional collaboration, and deeper reflective practice while maintaining scientific accuracy. Indeed, the study demonstrates that culture-based PLCs offer a sustainable and contextually responsive approach to enhancing teacher engagement and professional learning in IPEd biology instruction.

Keywords: Indigenous Peoples Education; teacher engagement; professional learning community; sequential explanatory mixed methods; biology teaching

INTRODUCTION

Teacher engagement is widely recognized as a central factor in the effectiveness of professional learning and instructional improvement, particularly in science education. Engaged teachers are more likely to participate actively in collaborative learning, reflect on their practice, and sustain innovations in classroom instruction. In culturally diverse contexts, such as Indigenous Peoples Education (IPEd), teacher engagement becomes even more significant as educators navigate the integration of culturally grounded knowledge with formal scientific concepts.

In the Philippines, the IPEd Program emphasizes culturally responsive, community-based, and contextually relevant teaching to address the educational needs of Indigenous learners. Central to this mandate is the integration of Indigenous Knowledge Systems and Practices (IKSP) into classroom instruction. However, biology teaching within IPEd contexts presents persistent challenges. Teachers often report limited confidence, insufficient resources, and tensions between maintaining scientific accuracy and honoring Indigenous ways of knowing. These challenges underscore the need for professional learning models that are collaborative, culturally grounded, and responsive to teachers' instructional realities.

Professional Learning Communities (PLCs) have been shown to support teacher learning through shared goals, collaborative inquiry, reflective dialogue, and collective responsibility for practice. When designed as culture-based spaces, PLCs can serve as platforms where teachers, researchers, and Indigenous community members collaboratively construct knowledge, develop instructional resources, and reflect on culturally responsive

pedagogy. Such PLCs move beyond conventional top-down training by positioning teachers as active contributors and co-learners within professional development processes.

Despite growing interest in culturally responsive PLCs, empirical studies examining teacher engagement within culture-based PLCs for science education—particularly biology teaching in IPed contexts—remain limited. Moreover, few studies have employed mixed-methods approaches that not only measure engagement but also explain how and why teachers engage in these collaborative spaces. Addressing this gap, the present study investigates the engagement of Indigenous Peoples Education teachers in a culture-based Professional Learning Community for biology teaching using a sequential explanatory mixed-methods design. By examining teachers' affective, behavioral, and cognitive engagement, this study aims to contribute to the literature on culturally responsive science education and offer insights into sustainable professional learning models for Indigenous contexts.

Research objective

This study aimed to investigate Indigenous Peoples Education (IPed) teachers' engagement in a culture-based Professional Learning Community (PLC for biology teaching) using a sequential explanatory mixed-methods approach. Guided by multidimensional engagement theory, the study quantitatively examined teachers' affective, behavioral, and cognitive engagement during participation in the PLC and qualitatively explained these engagement dimensions by exploring teachers' lived experiences, perceptions, and reflective practices within the collaborative professional learning process.

Hypothesis

Indigenous Peoples Education (IPed) teachers exhibit significant affective, behavioral, and cognitive engagement in a culture-based Professional Learning Community for biology teaching.

THEORETICAL FRAMEWORK

This study is anchored on the multidimensional theory of engagement, sociocultural learning theory, and culturally responsive pedagogy to explain Indigenous Peoples Education (IPed) teachers' engagement in a culture-based Professional Learning Community (PLC) for biology teaching. Teacher engagement is conceptualized as a multidimensional construct comprising affective, behavioral, and cognitive dimensions (Fredricks, Blumenfeld, & Paris, 2004; Klassen et al., 2013). Affective engagement refers to teachers' emotional responses to professional learning, including interest, motivation, confidence, and sense of belonging; behavioral engagement involves active participation in PLC activities such as collaboration and resource co-development; and cognitive engagement reflects teachers' reflective thinking and deliberate efforts to integrate Indigenous Knowledge Systems and Practices (IKSP) with formal biology concepts while maintaining scientific accuracy. Engagement theory suggests that professional learning environments characterized by relevance, collaboration, and shared purpose promote sustained instructional improvement (Kahn, 1990; Klassen et al., 2013).

The framework is further informed by sociocultural learning theory (Vygotsky, 1978) and the concept of communities of practice (Lave & Wenger, 1991), which view learning as socially mediated through interaction and participation in shared professional activities. Within this lens, the PLC functions as a collaborative space where teachers, researchers, and Indigenous community members co-construct scientific knowledge and IKSP through dialogue, reflective inquiry, and collective problem-solving. The involvement of Indigenous elders situates biology teaching within culturally meaningful contexts, shaping teacher engagement as a socially and culturally embedded process.

This study also draws on culturally responsive pedagogy (Ladson-Billings, 1995; Gay, 2010), which emphasizes the validation and integration of learners' cultural knowledge into instruction. In IPed contexts, this perspective recognizes IKSP as a legitimate foundation for science teaching. Scholars argue that effective Indigenous science education requires navigating the interface between Indigenous knowledge and Western science while respecting both epistemologies (Aikenhead & Michell, 2011). Culture-based PLCs support this process by enhancing teachers' cultural competence, confidence, and professional agency, thereby strengthening engagement and ownership of learning (Villegas & Lucas, 2002).

Taken together, these theoretical perspectives position the culture-based PLC as a socially and culturally situated professional learning environment that activates teachers' affective, behavioral, and cognitive engagement. Within the sequential explanatory mixed-methods design, quantitative findings establish the level of engagement, while qualitative findings explain how sociocultural interaction and culturally grounded collaboration sustain teacher engagement in IPed biology teaching.

RESEARCH METHODOLOGY

This study employed a sequential explanatory mixed-methods design to examine Indigenous Peoples Education (IPed) teachers' engagement in the Bandí Collaborative Bootcamp, a culture-based Professional Learning Community (PLC) for biology teaching. Bandí, a Subanen term meaning "treasure," symbolizes the value placed on Indigenous Knowledge Systems and Practices (IKSP) and teachers' shared professional learning. The design consisted of two connected phases: an initial quantitative phase to measure teachers' affective, behavioral, and cognitive engagement, followed by a qualitative phase to explain and contextualize the quantitative findings. This approach enabled a comprehensive examination of both the level and nature of teacher engagement within a culturally grounded professional learning environment.

The study was conducted during the three-day Bandí Collaborative Bootcamp and involved twenty (20) teacher participants from the select IPed-implementing schools in the Division of Misamis Occidental, together with researchers, Subanen elders, and community members. The Bootcamp was designed as a participatory PLC focused on the co-creation of the Bandíserye, a culture-based biology learning resource integrating Subanen Indigenous Knowledge Systems and Practices (IKSP). Participants represented varied professional backgrounds in terms of teaching experience, educational preparation, and ethnic affiliation, supporting heterogeneous collaboration and shared professional learning.

Quantitative data were collected using a structured engagement survey aligned with established multidimensional engagement frameworks, complemented by participation records documenting attendance and involvement in collaborative tasks. Descriptive statistics were used to determine engagement levels across affective, behavioral, and cognitive dimensions. Following quantitative analysis, qualitative data were gathered through focus group discussions. These data were analyzed using thematic analysis to identify experiences, processes, and challenges influencing teacher engagement.

Integration of quantitative and qualitative findings occurred during the interpretation stage, where qualitative themes were used to explain and contextualize quantitative trends. Ethical protocols were strictly observed throughout the study, including informed consent, voluntary participation, and the right to withdraw at any stage without penalty. Participant confidentiality and anonymity were ensured through the use of coded identifiers and secure data storage. In compliance with the Data Privacy Act of 2012 (Republic Act No. 10173), all personal information was collected solely for research purposes, stored in password-protected files, and accessed only by the research team. Respectful and ethical engagement with Indigenous communities was upheld by recognizing cultural protocols, securing community consent, and ensuring that Indigenous Knowledge Systems and Practices (IKSP) were represented accurately and responsibly.

Research findings

Characteristics of Teacher Participants

Table 1 presents the personal, educational, and professional profiles of the twenty (20) teacher participants in the Bandí Collaborative Bootcamp. The profiles were examined to assess teachers' capacity and readiness to integrate Indigenous Knowledge Systems and Practices (IKSP) into classroom instruction within the Indigenous Peoples Education (IPed) context. Participant information included sex, age, teaching experience, position, educational background and trainings, Subanen ethnic affiliation, and level of interest in IKSP integration. The participants represented a diverse teaching workforce, ranging from early-career teachers to educators with nearly two decades of experience. Such heterogeneity is important, as Professional Learning Communities benefit from the complementary contributions of novice and experienced teachers (Hord, 2004; Stoll et al., 2006). Most participants held education degrees, with several pursuing or having completed graduate studies, and many had attended IPed-related trainings such as IPed retooling, Subanen orthography workshops, and

MATATAG Science training. Prior exposure to culturally responsive professional development is significant, as it enhances teachers' confidence and willingness to integrate Indigenous knowledge into instruction (Gay, 2018; DepEd, 2017).

Table 1. Teacher Participants' Profiles and Readiness for IKSP Integration

Code	Sex	Age	Teaching Experience (Years)	Position	Educational Background / Trainings Attended	Subanen Affiliation	Interest in IKSP Integration
TP1	Female	43	12	Head Teacher III	B.Ed. Home Economics Retooling IPEd Supervision	No	High
TP2	Female	31	6	Teacher II	M. Ed. General Science	No	Moderate
TP3	Female	34	11	Teacher III	M. Ed. Science and Health Retooling IPEd	Yes	High
TP4	Female	29	0.5	Teacher I	BSEd Biology NLC	No	Moderate
TP5	Female	34	9.8	Teacher I	M. Ed. Gen.Ed. Ginsalugën Subanën Orthography	Yes	High
TP6	Female	30	3	Teacher I	B.Ed. Biology MATATAG Science	Yes	High
TP7	Male	36	11	Teacher III	B.Ed.	Yes	High
TP8	Female	32	9	Teacher III	M.Ed. Educational Mngt IPEd Summit 2024	Yes	High
TP9	Female	35	12	Teacher III	M.Ed. English / Writeshop in Subanën Orthography	Yes	High
TP10	Female	37	15	Teacher III	MA Teaching Arts (Ongoing) / Ginsalugën Subanen Orthography	Yes	High
TP11	Female	30	1.3	Teacher I	B. Ed. Science and Health	No	Moderate
TP12	Female	33	6	Teacher I	B. Ed.	Yes	High
TP13	Female	28	4	Teacher I	B. Ed. TLE	No	Moderate
TP14	Female	39	9	Teacher I	B. Ed. ECE	No	High
TP15	Female	29	5	Teacher I	B. Ed. English	No	High
TP16	Male	26	4	Substitute	B. Ed. Social Studies	No	High

TP17	Female	34	0.3	Volunteer	B. Ed. General Science	No	High
TP18	Female	44	19	Teacher III	MA EM (Ongoing) / Ginsalugèn Subanen Orthography	Yes	High
TP19	Female	36	14	Teacher II	M. Ed. Math / Retooling IPEd	No	High
TP20	Male	38	12	Teacher III	B. Ed. Math / Retooling IPEd	No	High

Note: Subanen Ethnic Affiliation indicates whether the teacher is ethnically Subanen. Interest in IKSP Integration reflects motivation and readiness to integrate Subanen cultural knowledge into teaching.

The Bandí Collaborative Bootcamp as a Culture-Based PLC

The Bandí Collaborative Bootcamp operationalized a culture-based Professional Learning Community (PLC) by intentionally structuring collaborative activities that fostered shared vision, collective inquiry, reflective practice, and distributed leadership among teachers, cultural bearers, and researchers. As summarized in Table 2, the alignment of activities, purposes, and skill outcomes across the three-day Bootcamp demonstrates how professional learning was situated within Indigenous contexts while remaining anchored in curriculum standards and pedagogical soundness.

Table 2. Alignment of Activities and Outcomes in the Bandí PLC

Activity	Description/ Purpose	Learning Outcome / Skill Focus
Day 1: Laying the Groundwork (Culture, Curriculum, and Collaboration)		
Session 1: The Bandíserye Framework	Present the conceptual foundations, goals, and intended outputs of the Bandíserye as a culture-based science pedagogy.	Conceptual understanding, instructional leadership
Session 2: Weaving Culture into Curriculum with Heart and Heritage	Explore how culture, identity, and lived experience can be meaningfully integrated into formal curriculum.	Cultural responsiveness, curriculum innovation
Session 3: Frameworks for Culture-Based Curriculum Development and Assessment	Introduce curriculum design and assessment frameworks aligned with IPEd, MELCs, and MATATAG Science.	Curriculum design competence, assessment literacy
Session 4: Biology Concepts and IKSP Integration	Deepen understanding of how core biology concepts align with Subanen Indigenous Knowledge Systems and Practices.	Pedagogical content knowledge, contextualization skills
Session 5: Cultural Identity and the Subanen Way of Life	Cultural bearers share Subanen worldview, traditions, and practices relevant to science learning.	Cultural literacy, ethical leadership
Workshop 1: Initial Stage – Storyline Brainstorming	Participants collaboratively generate Bandíserye story ideas grounded in Subanen culture and community life.	Creative leadership, collaborative inquiry

Workshop 2: Curriculum Mapping and Alignment Activity	Teams align story ideas with MELCs and MATATAG Science to ensure curriculum coherence.	Standards-based planning, curriculum leadership
Workshop 3: Collaborative Synthesis and Refinement	Teachers, elders, and facilitators refine storylines and science concepts through dialogue and consensus-building.	Teamwork, shared decisionmaking
Day 2: From Story to Science (Designing and Developing Bandíserye)		
Workshop 4: Outline Stage – Storyboarding (with QR Code Integration)	Transform initial storyline ideas into structured storyboards that organize visuals, narratives, and learning intent, including the planned integration of QR codes linking to digital storytelling, audio narrations, and supplementary science content.	Instructional design competence, creative leadership, educational technology integration
Workshop 5: Defining Learning Outcomes and Competency Targets	Teams explicitly identify intended learning outcomes and map them to MELCs and the MATATAG Science Curriculum.	Outcomes-based planning, curriculum alignment leadership
Workshop 6: Integration of Biology Concepts	Teachers embed accurate, developmentally appropriate biology concepts within the storyline and scenes.	Pedagogical content knowledge, scientific accuracy
Workshop 7: IKSP and Cultural Context Integration	Cultural bearers and teachers collaboratively ensure authentic, respectful, and meaningful representation of Subanen IKSP.	Cultural responsiveness, ethical leadership
Workshop 8: Peer Review and Collaborative Refinement	Groups present draft storyboards and engage in structured peer critique to improve coherence, relevance, and instructional clarity.	Professional collaboration, constructive communication
Workshop 9: Writing Stage – Script Development	Participants convert approved storyboards into written Bandíserye scripts, including dialogue, narration, and scene descriptions.	Academic writing skills, narrative coherence
Workshop 10: Ensuring Age-Appropriate and Inclusive Language	Scripts are refined to ensure clarity, inclusivity, and suitability to the learners’ cognitive and cultural contexts.	Inclusive pedagogy, learnercentered leadership
Workshop 11: Plenary Presentation and Synthesis	Groups present completed storyboards and scripts for collective feedback and synthesis of best practices.	Presentation skills, collective accountability, reflective leadership
Day 3: Pilot Testing and Final Refinement (From Design to Classroom Readiness)		

Workshop 12: Orientation Pilot Testing	Participants are briefed on the purpose, criteria, and process of pilot testing Bandíserye materials.	Evaluation literacy, readiness for evidence-based practice
Group-Based Pilot Testing	Teams implement Bandíserye materials in simulated classroom settings using mock learners.	Instructional leadership, application of theory to practice
Observation and Evidence Documentation	Participants systematically observe learner engagement, comprehension, and challenges during pilot testing.	Analytical thinking, datainformed decision-making
Peer Feedback and Dialogue	Groups present pilot testing experiences and receive targeted feedback focused on science accuracy, cultural relevance, and pedagogy.	Collaborative leadership, professional dialogue
Workshop 4: Formative Assessment Development	Participants design culturally responsive formative assessment tools aligned with biology concepts and IKSP.	Assessment literacy, instructional decision-making
Gallery Walk and Structured Peer Review	Outputs are displayed for peer review using established rubrics and criteria.	Critical feedback skills, collegial learning culture
Revision and Refinement Session	Teams revise Bandíserye materials based on pilot data and peer feedback.	Adaptive leadership, continuous improvement mindset

Multidimensional Engagements – Affective, Behavioral, Cognitive

Table 3 presents teachers’ affective engagement during the Bandí Collaborative Bootcamp was very high ($M = 3.55$, $SD = 0.562$). Teachers reported being motivated to participate, enjoying collaboration, and feeling a strong sense of belonging in the Bootcamp. The highest-rated indicator was feeling proud to be part of a culturebased professional learning community ($M = 3.90$, $SD = 0.308$), showing that the experience had strong emotional meaning for participants.

Table 3. Teacher Participants’ Affective Engagement

Indicators	Mean	SD	Interpretation
I felt motivated to participate actively in the Bandí Collaborative Bootcamp activities.	3.50	0.513	Very High
I enjoyed collaborating with fellow teachers, researchers, and community members during the Bootcamp.	3.40	0.681	Very High
I felt a strong sense of belonging within the Bandí Collaborative Bootcamp community.	3.55	0.605	Very High
The inclusion of Subanen elders and cultural knowledge made the learning experience meaningful for me.	3.55	0.605	Very High

I felt respected and valued when sharing my ideas and experiences during Bootcamp discussions.	3.55	0.510	Very High
The Bootcamp increased my interest in integrating Indigenous Knowledge Systems and Practices (IKSP) into my teaching.	3.60	0.598	Very High
I felt emotionally invested in the development of the Bandíserye learning resources.	3.50	0.513	Very High
I felt encouraged to express my views during collaborative discussions.	3.45	0.686	Very High
I felt inspired by the shared vision and goals of the Bandí Collaborative Bootcamp.	3.55	0.605	Very High
I felt proud to be part of a culture-based professional learning community.	3.90	0.308	Very High
Overall	3.55	0.562	Very High

Hypothetical Mean Range: 1.00 – 1.75=Very Low; 1.76-2.50=Low; 2.51-3.25=High; 3.26-4.00=Very High

As shown in Table 4, teachers' behavioral engagement during the Bandí Collaborative Bootcamp was very high ($M = 3.65$, $SD = 0.501$). Participants actively joined group discussions and collaborative tasks ($M = 3.80$), consistently attended sessions ($M = 3.55$), and contributed ideas, materials, and feedback to the development of the Bandíserye ($M = 3.70$). High ratings for supporting colleagues, volunteering for tasks, and following through on commitments further indicate strong accountability and shared responsibility within the PLC.

Table 4. Teacher Participants' Behavioral Engagement

Indicators	Mean	SD	Interpretation
I actively participated in group discussions and collaborative tasks during the Bootcamp.	3.80	0.410	Very High
I consistently attended Bootcamp sessions and PLC-related activities.	3.55	0.686	Very High
I contributed ideas, materials, or feedback to the development of the Bandíserye.	3.70	0.470	Very High
I worked collaboratively with colleagues and community members to solve instructional challenges.	3.70	0.470	Very High
I applied agreed-upon tasks or action plans between Bootcamp sessions.	3.55	0.605	Very High
I engaged in reflective activities such as sharing classroom experiences and challenges.	3.60	0.598	Very High
I supported my colleagues by listening, giving feedback, and sharing teaching strategies.	3.70	0.470	Very High
I volunteered for tasks or roles during Bootcamp activities.	3.55	0.605	Very High
I followed through on commitments made during PLC meetings.	3.70	0.470	Very High
I shared resources or practices from the Bootcamp with other teachers.	3.66	0.223	Very High
Overall	3.65	0.501	Very High

Hypothetical Mean Range: 1.00 – 1.75=Very Low; 1.76-2.50=Low; 2.51-3.25=High; 3.26-4.00=Very High

Table 5 shows that teachers demonstrated very high cognitive engagement (M =3.67, SD =0.501). Teachers reported exerting effort to understand IKSP integration strategies, reflecting on their current teaching practices, and considering how Bootcamp learning could support long-term instructional improvement. The highest-rated indicator—gaining new insights on how collaborative inquiry enhances teaching and learning (M =3.90, SD =0.308)—highlights the depth of teachers’ intellectual involvement.

Table 5. Teacher Participants’ Cognitive Engagement

Indicators	Mean	SD	Interpretation
I thoughtfully reflected on how Subanen IKSP connects with biology concepts discussed in the Bootcamp.	3.65	0.489	Very High
I exerted effort to understand new strategies for integrating IKSP into science lessons.	3.65	0.489	Very High
I critically examined my existing teaching practices during the Bootcamp.	3.85	0.366	Very High
I explored ways to align Bandíserye materials with curriculum standards (e.g., MATATAG, IPed).	3.60	0.503	Very High
I was willing to revise my lesson ideas based on feedback from the PLC.	3.55	0.759	Very High
The Bootcamp challenged me to think deeply about culturally responsive pedagogy.	3.70	0.470	Very High
I developed new insights on how collaborative inquiry improves teaching and learning.	3.90	0.308	Very High
I analyzed classroom problems using ideas discussed during the Bootcamp.	3.50	0.607	Very High
I considered multiple perspectives when planning IKSPintegrated lessons.	3.50	0.607	Very High
I connected Bootcamp learning to long-term improvements in my teaching practice.	3.80	0.410	Very High
Overall	3.67	0.501	Very High

Hypothetical Mean Range: 1.00 – 1.75=Very Low; 1.76-2.50=Low; 2.51-3.25=High; 3.26-4.00=Very High

Key Experiences Influencing Teachers’ Engagement

Table 6 presents the key experiences that motivated and sustained teacher engagement during the Bandí Collaborative Bootcamp. These experiences highlight how affective, behavioral, and cognitive dimensions of engagement were activated through culturally grounded, collaborative, and reflective professional learning processes

Table 16. Experiences Driving Teacher Engagement During the Bandí Collaborative Bootcamp

Engagement Dimension	Theme	Description	Sample Participant Responses

Affective Engagement	Cultural Meaning and Identity Affirmation	Teachers experienced pride, fulfillment, and emotional connection when Subanen IKSP was recognized as legitimate science knowledge.	“It felt fulfilling to see Subanen knowledge treated as important in science. I felt proud to be part of this process.” (TP3) “I felt happy and motivated because our culture was not just included but respected.” (TP6)
	Sense of Belonging and Respect	A supportive PLC environment encouraged teachers to share ideas without fear of judgment.	“I felt safe sharing my ideas because everyone listened and respected each other.” (TP7) “The presence of elders made me feel that this work truly mattered.” (TP9)
Behavioral Engagement	Active Collaboration and Shared Responsibility	Teachers were motivated to participate because tasks were collective and purpose-driven.	“We were not just listening—we were really doing the work together.” (TP10) “Everyone had a role, so I felt responsible to contribute.” (TP4)
Engagement Dimension	Theme	Description	Sample Participant Responses
Cognitive Engagement	Reflective and Meaningful Learning	Teachers engaged deeply as they connected IKSP with biology concepts and teaching practice.	“The discussions made me rethink how I teach science.” (TP1) “I realized many biology concepts are already present in our community practices.” (TP5)

DISCUSSION

This study examined Indigenous Peoples Education (IPEd) teachers’ engagement in a culture-based Professional Learning Community (PLC) for biology teaching using a sequential explanatory mixed-methods design. The findings provide strong evidence that the Bandí Collaborative Bootcamp fostered high levels of affective, behavioral, and cognitive engagement, supporting the study’s hypothesis and extending existing literature on culturally responsive professional learning in Indigenous contexts.

Consistent with multidimensional engagement theory, the quantitative results demonstrate that teacher engagement during the Bootcamp was holistic rather than fragmented. Teachers were not only behaviorally active but also emotionally invested and cognitively engaged. This pattern aligns with prior research suggesting that meaningful professional learning occurs when affective, behavioral, and cognitive dimensions of engagement interact synergistically (Fredricks et al., 2004; Klassen et al., 2013). Recent studies on teacher professional development further emphasize that engagement is maximized when learning experiences are relevant, collaborative, and emotionally meaningful (Desimone & Garet, 2015; Opfer & Pedder, 2011). The very high affective engagement observed—particularly teachers’ pride and sense of belonging—indicates that culturebased PLCs can create emotionally affirming spaces that motivate sustained participation. In Indigenous education contexts, such emotional connection is especially important, as professional learning often involves navigating issues of cultural identity, legitimacy, and responsibility (Castagno & Brayboy, 2008; Paris & Alim, 2017).

The findings also support sociocultural learning theory, which views learning as socially mediated through interaction and participation in shared practices (Vygotsky, 1978). Teachers’ behavioral engagement was strengthened by the collaborative structure of the Bootcamp, where shared tasks, collective outputs, and peer accountability encouraged active participation. This resonates with research on effective PLCs, which highlights

joint work, shared goals, and collective responsibility as key mechanisms for sustained engagement and instructional improvement (DuFour & Eaker, 1998; Stoll et al., 2006). Rather than functioning as recipients of externally imposed training, teachers acted as co-designers of knowledge alongside researchers and cultural bearers. This mode of participation reflects the principles of communities of practice, where learning emerges through collective inquiry, legitimate participation, and shared problem-solving (Lave & Wenger, 1991; Wenger, 1998). The sustained interaction among teachers, Subanen elders, and community members positioned engagement as a socially situated process shaped by relationships, dialogue, and shared meaning.

Cognitive engagement findings further highlight the intellectual value of culture-based PLCs. Teachers reported deep reflection, curriculum analysis, and strategic thinking as they aligned Indigenous Knowledge Systems and Practices (IKSP) with biology concepts and formal curriculum standards. This aligns with literature emphasizing that high-quality professional learning requires opportunities for teachers to engage in inquiry, reflection, and problem-solving connected to their instructional contexts (Borko, 2004; Darling-Hammond et al., 2017). Importantly, challenges related to curriculum alignment and scientific accuracy did not diminish engagement; instead, they functioned as productive difficulties that stimulated higher-order thinking and collaborative sense-making. This supports research indicating that cognitively demanding professional learning—when scaffolded through collaboration and expert support—enhances teacher learning and pedagogical expertise rather than causing disengagement (Timperley et al., 2007; Windschitl et al., 2018).

The qualitative findings underscore the central role of culturally responsive pedagogy in sustaining engagement. Teachers' affective and cognitive engagement was strongly influenced by the recognition of Subanen IKSP as legitimate and valuable knowledge in science education. This finding aligns with decolonizing and culturally sustaining education literature, which argues that validating Indigenous epistemologies strengthens both teacher agency and instructional relevance (Battiste, 2002; Smith, 2012). Cultural affirmation, respect for elders, and ethical representation of Indigenous knowledge fostered professional confidence, particularly among teachers working in Indigenous communities. Previous studies have shown that when teachers perceive professional learning as respectful of community knowledge and cultural protocols, they demonstrate stronger commitment, reflective practice, and instructional innovation (McKinley & Stewart, 2012; Bang et al., 2018).

Altogether, the findings suggest that the Bandí Collaborative Bootcamp succeeded in moving beyond conventional, top-down professional development models that often marginalize local knowledge and teacher voice. By integrating culture, collaboration, and reflective inquiry, the Bootcamp created conditions that supported sustained, multidimensional engagement and meaningful professional learning. This study contributes to the growing body of research on Indigenous and culture-based professional learning by empirically demonstrating how PLCs grounded in Indigenous Knowledge Systems can strengthen teacher engagement and instructional capacity in IPEd biology teaching. Moreover, it reinforces calls in the literature to position Indigenous knowledge holders as co-educators and co-creators in professional learning processes, advancing ethical, epistemological, and pedagogical equity in Indigenous education (Aikenhead & Michell, 2011; Barnhardt & Kawagley, 2005).

CONCLUSION

This study concludes that the Bandí Collaborative Bootcamp is an effective culture-based Professional Learning Community (PLC) for enhancing IPEd teachers' engagement and professional learning in biology. Using a sequential explanatory mixed-methods design, the findings show consistently high affective, behavioral, and cognitive engagement, confirming that teacher engagement in culture-based professional learning is multidimensional and interconnected.

Affective engagement, reflected in teachers' sense of pride, belonging, and cultural affirmation, was central to sustaining participation. The recognition of Subanen Indigenous Knowledge Systems and Practices (IKSP) as legitimate science knowledge created an emotionally affirming learning space essential in Indigenous education contexts. Behavioral engagement was strengthened through collaborative structures that positioned teachers as co-designers rather than passive recipients of training. Cognitive engagement was evident in teachers' deep reflection and problem-solving as they aligned IKSP with biology concepts and curriculum standards, with challenges serving as productive learning opportunities.

Indeed, the Bandí Collaborative Bootcamp moves beyond traditional top-down professional development by integrating culture, collaboration, and reflective inquiry. It demonstrates that culture-based PLCs are a sustainable and effective model for strengthening teacher engagement and instructional capacity in Indigenous Peoples Education, particularly in biology teaching.

Suggestions

This study suggests that culture-based Professional Learning Communities (PLCs) be sustained and expanded within Indigenous Peoples Education (IPEd) to strengthen teacher engagement and culturally responsive biology teaching. Teachers should be encouraged to engage in collaborative inquiry and reflective practice that ethically integrates Indigenous Knowledge Systems and Practices (IKSP) with scientific concepts. School leaders and policymakers are urged to provide structural and policy support for culture-based PLCs, including time, resources, and partnerships with Indigenous communities. Future research may further examine the long-term instructional and learner impacts of culture-based PLCs across diverse Indigenous contexts.

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