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Pre-Service Teachers' Integration of Indigenous Knowledge Practices into Science Teaching: Evidence of Core Competency Manifestations

Pre-Service Teachers' Integration of Indigenous Knowledge Practices into Science Teaching: Evidence of Core Competency Manifestations

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Abstract
This study explored the core competencies evidenced by pre-service teachers as they engaged with Indigenous Knowledge Practices (IKPs) and considered their integration into science teaching during Supported Teaching in Schools (STS) in Ghana. The study focused on *pito* brewing and *akpeteshie* distillation as culturally situated contexts through which pre-service teachers examined scientific ideas associated with separation of mixtures and explored connections between indigenous knowledge and formal science education. A qualitative exploratory design was employed. Fifteen purposively selected third-year pre-service teachers undertaking STS in 15 Basic 4 classrooms participated in the study. The interview transcripts and observation notes were analysed thematically. NVivo 2020 was used to organise the qualitative dataset, manage codes and retrieve coded excerpts. The software supported data-management and coding. The findings provided evidence of opportunities for pre-service teachers to demonstrate communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy. However, evidence of critical thinking and problem-solving and creativity and innovation was limited. The findings suggest that culturally situated IKPs can provide relevant contexts for demonstrating selected core competencies, but their integration alone does not guarantee the development or manifestation of higher-order competencies. The study highlights the importance of deliberately structuring IKP-based science activities to create opportunities for inquiry, analysis, problem-solving and creative thinking. Implications for teacher education and the integration of culturally relevant knowledge into science teaching are discussed.

Introduction
Scientific knowledge is situated within a socio-cultural context, where Indigenous Knowledge Practices (IKPs) serve as valuable resources for ethical teaching, community engagement, and meaningful learning (Mapira & Mazambara, 2013). By drawing on community practices grounded in scientific principles, educators can support both conceptual understanding and the development of core competencies. Core competencies refer to the integrated knowledge, skills, and dispositions

learners require for intellectual, personal, social, and emotional development and for lifelong learning (National Council for Curriculum and Assessment [NaCCA], 2019).

Ghana's Standards-Based Curriculum identifies competencies intended to support learners' intellectual, social, personal and civic development, including communication and collaboration, critical thinking and problem-solving, creativity and innovation, cultural identity and global citizenship, personal development and leadership, and digital literacy (NaCCA, 2019). Competency development extends beyond schooling into social, educational, and professional contexts and is central to Ghana's standards-based curriculum (Niu et al, 2025; Seprie et al., 2025).

In the present study, these competencies are considered primarily from the perspective of pre-service teacher development, rather than as evidence that children should directly participate in alcohol-related production practices. The focus is therefore on what pre-service teachers learn when they investigate, document, discuss, and pedagogically interpret selected IKPs, and on their ability to translate such knowledge into safe and appropriate science teaching resources and activities.

Ghana's recent educational reforms emphasise equipping learners with skills needed to adapt to their environment and contribute effectively to society. Accordingly, the curriculum prioritises competencies such as communication and collaboration, critical thinking and problem-solving, creativity and innovation, cultural identity and global citizenship, personal development and leadership, and digital literacy (NaCCA, 2019). Consequently, the present study does not assume that engagement with IKPs automatically develops higher-order competencies. Rather, it examines the extent to which particular competencies are evident in the participants' engagement with and interpretation of IKP-based science learning activities. Where competencies such as critical thinking, problem-solving or creativity are not demonstrated in the findings, because the study was qualitative and exploratory, observed behaviours were interpreted as evidence of competency manifestation. This position provides a more accurate alignment between the conceptualisation of competency development and the empirical evidence generated by the study.

Ghana's educational reforms emphasise the development of competencies that enable learners to use knowledge effectively, participate responsibly in society and respond to changing social and environmental circumstances (NaCCA, 2019). For pre-service teachers, this expectation is particularly significant because they are required not only to acquire these competencies themselves but also to develop the pedagogical capacity to foster them in school learners. Teacher education therefore provides an important setting in which pre-service teachers can critically examine culturally situated knowledge and learn to design learning experiences that connect curriculum content with learners' experiences while maintaining appropriate ethical, safety and pedagogical boundaries. The following sections discuss each competency in detail.

Critical Thinking and Problem-Solving

According to the NaCCA (2019), for learners to be able to analyse and solve problems, their cognitive and reasoning skills must be developed through critical thinking and problem-solving. Learners, whose critical thinking and problem-solving abilities are well-developed can analyse events and select the best course of action out of a number of options, by drawing on their own experiences. It is therefore important for learners to accept the challenge head-on and persevere to be accountable for their own learning. The British Columbia Ministry of Education (2015) also captured critical thinking as a core competency for the proper growth and development of learners. It is explained that the information, abilities, and strategies identified with intellectual growth are all part of thinking competency. Learners transfer knowledge and concepts from one subject to another by drawing on their capacity for critical thinking. In addition to mental routines and metacognitive awareness,

thinking competency also includes specialised thinking skills (Dyjur et al., 2025). These are utilised to process information from various sources, including ideas and feelings that come from the subconscious and unconscious mind as well as from embodied cognition, in order to produce new understandings (British Columbia Ministry of Education, 2015).

Creativity and Innovation

Innovation and creativity produce fresh, different, and original ideas as well as the ability to connect disparate concepts (UNESCO's Strategy on Technological Innovation in Education (2022–2025), (UNESCO, 2021). By helping learners develop new methods for approaching challenges and the tools to do so, creativity and innovation foster the growth of entrepreneurial abilities in learners (Johari & Singh, 2025). It necessitates creative thought, the arts, technology, and business (James et al., 2025). Similarly, learners endowed with this skill are independent-minded individuals capable of generating their own ideas (NaCCA, 2019). Creative and innovative learners possess a risk-taking spirit and are determined to overcome personal obstacles to reveal their creative selves and advance new works or ideas (Henriksen et al., 2021). If well-developed in learners, creativity and innovation competencies help them question existing paradigms and propose alternatives without being constrained by established approaches or others' anticipated responses (Isabirye et al., 2025).

Communication and Collaboration

This competency encourages learners to develop the ability to use texts, symbols, and spoken language to share information about themselves and their experiences (NaCCA, 2019). Learners actively participate by offering their thoughts freely (Clark et al., 2009). When they converse with people, they listen carefully to what they say and learn from them. Additionally, they value and respect other people's opinions. The core competency of communication and collaboration encompasses the knowledge, abilities, strategies, and attitudes associated with interpersonal relationships (UNICEF Europe and Central Asia Regional Office et al., 2024). Learners learn to collaborate and communicate ideas, express their individuality, advance their learning, and accomplish tasks through co-operation (NaCCA, 2019). Through communication and collaboration, they acquire, develop, and transform ideas and information. They establish connections with others. Finding fulfilment, purpose, and joy all depends on having strong communication and collaboration skills (Babalola, 2024; Schmidt et al., 2023; British Columbia Ministry of Education, 2015; Laal & Ghodsi, 2012)

Cultural Identity and Global Citizenship

Cultural identity and global citizenship emphasise belonging to a shared humanity and the interconnectedness of local, national, and global contexts (UNESCO, 2017). UNESCO (2017) highlights their importance in achieving education-related Sustainable Development Goals, particularly through promoting human rights, peace, and sustainability. Education for global citizenship fosters knowledge, values, and actions that encourage respect for cultural diversity and social responsibility (Fang et al., 2023). Learners who maintain cultural identity while developing global awareness demonstrate empathy, respect, and active civic engagement (Enamhe et al., 2025). Such education equips learners with the skills and attitudes needed to contribute meaningfully to national and global socioeconomic development and to critically engage with cultural and global trends (NaCCA, 2019).

Personal Development and Leadership

Personal development and leadership is the collection of skills known as personal and social competency in relation to how learners see themselves in the world, both as individuals and as contributors to their communities and societies. What learners need to thrive as individuals, to understand and care about themselves and others, and to identify and fulfil their goals in the world are all parts of personal and social competency (British Columbia Ministry of Education, 2015).

Building self-esteem and increasing self-awareness are essential aspects of this competency. It also comprises recognising and nurturing abilities as well as realising goals and desires. Learners can learn from past mistakes and failures. They learn the abilities necessary to help others meet their needs. It entails appreciating the importance of values, such as honesty and empathy, and putting other people's needs first. Learning to differentiate between right and wrong is made possible through personal development and leadership. It also helps learners gain tenacity, resilience, and self-assurance. They also develop a high sense of self-control and responsibility, both of which are necessary for lifelong learning (NaCCA, 2019).

According to Uaikhanova et al. (2022), leadership development involves more than students simply occupying formal leadership positions. It involves developing students' capacity to communicate, organiSe, interact with others, and take effective action. According to Schmalenbach et al. (2022), personal development and leadership can be fostered through experiential and collaborative learning activities that require learners to assume responsibility, work with others, solve problems, and reflect on their learning. Evidence from the LIFE programme demonstrates that participation in service-learning activities can contribute to learners' development of leadership, teamwork, strategic thinking and problem-solving skills, as well as personal growth (Schmalenbach et al., 2022). Such experiential approaches are relevant to Indigenous Knowledge Practice-based science learning because they provide learners with opportunities to collaborate, take initiative, communicate ideas, and apply scientific knowledge to culturally meaningful contexts.

Ermak (2025) identifies leadership skills as competencies that are important for learners' personal development, socialisation, and competitiveness in contemporary society. Leadership skills are a set of transferable competencies, rather than simply the ability to occupy a leadership position. Learners take responsibility and act without waiting for direction. He attests that cultural heritage can serve as a context for developing leadership competencies that foster personal development. Learners do not merely learn cultural information; they investigate heritage, produce knowledge products, work collaboratively, and communicate their findings. Thus, personal development and leadership develop through active, collaborative, and interdisciplinary learning rather than through explicit leadership instruction alone.

Personal development and leadership encompass learners' development of confidence, agency, responsibility, initiative, and the capacity to work constructively with others. In teacher education, these dispositions are important because pre-service teachers are expected not only to acquire subject knowledge but also to demonstrate initiative, confidence, and responsibility in planning and implementing learning activities. The integration of IKPs provided opportunities for participants to interact with indigenous practitioners, take responsibility for learning activities, and communicate culturally situated scientific knowledge.

Digital Literacy

Digital literacy involves the ability to communicate, learn, and explore using information and communication technologies (NaCCA, 2019). In teacher education, developing digitally literate learners emphasises training in technical skills and the effective application of digital tools in learning contexts (Marín & Castañeda, 2022; Admiraal et al., 2017). These skills equip learners with foundational knowledge for meaningful engagement with digital media. NaCCA (2019) further emphasises developing core competencies and scientific process skills to support problem-solving. Beyond scientific literacy, science education should promote social cohesion, aesthetic appreciation of nature, and stronger learner–environment connections (Silva et al., 2023). Indigenous Knowledge Practices (IKPs) are grounded in empirical observation and scientific principles, developed through

generations of experimentation and interaction with the environment. These practices provide culturally relevant insights that align with key scientific concepts taught in schools (Anor, 2024).

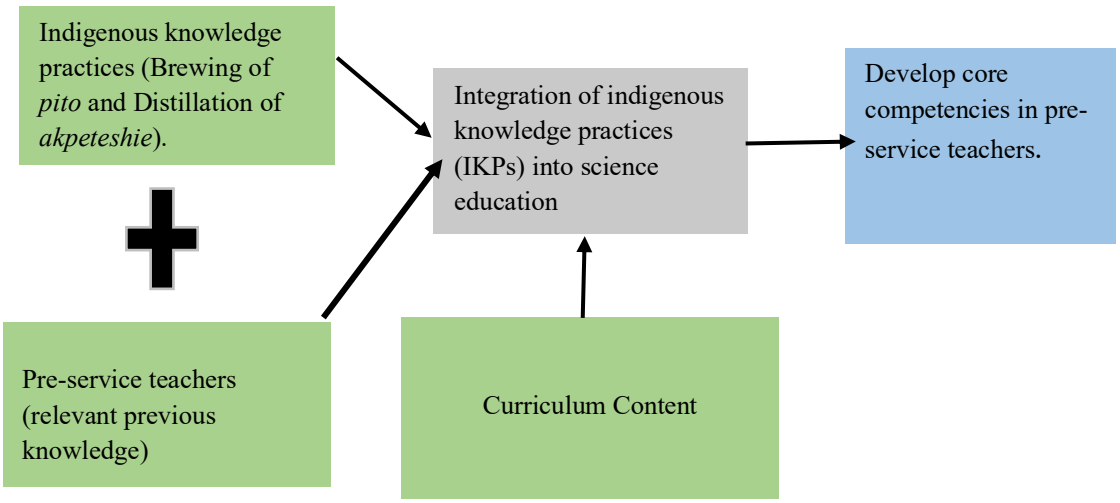
Although studies have examined the relevance of Indigenous Knowledge Practices in culturally responsive and contextually relevant science education, fewer studies have empirically examined the specific core competencies that pre-service teachers demonstrate when IKPs are deliberately connected to science teaching. Evidence is particularly limited regarding how pre-service teachers interpret community-based practices such as pito brewing and akpeteshie distillation in relation to the competency expectations of Ghana's Standards-Based Curriculum. This study therefore addresses a contextual and empirical gap by examining the competencies demonstrated by pre-service teachers in their engagement with IKP-based science activities in Supported Teaching in Schools. The study aimed to examine the core competencies evidenced by pre-service teachers as they engaged with and integrated Indigenous Knowledge Practices, specifically *pito* brewing and *akpeteshie* distillation, into science teaching during Supported Teaching in Schools.

The study sought to answer the following research question

*What core competencies do pre-service teachers demonstrate through the integration of Indigenous Knowledge Practices (pito brewing and akpeteshie distillation) in science lessons**?***

Theoretical Framework

This study is situated within Vygotsky's socio-cultural theory, which views learning as a socially and culturally mediated process. From this perspective, individuals develop knowledge through interaction with others and participation in activities situated within particular cultural and historical contexts (Vygotsky, 1978). Learning is therefore not viewed as an isolated cognitive activity but as a process shaped by social interaction, language, cultural practices and the tools available within the learner's environment.



A central principle of the socio-cultural perspective is the role of social interaction in knowledge construction. Learners develop understanding through dialogue with teachers, peers, and other knowledgeable members of their communities. In the present study, interactions among pre-service teachers, learners, and indigenous practitioners provided opportunities to discuss, explain, and

reinterpret scientific ideas associated with *pito* brewing and *akpeteshie* distillation. These interactions were particularly relevant because Indigenous Knowledge Practices are embedded in community activities and transmitted through participation, observation, demonstration, and dialogue.

Vygotsky's concept of mediation is also relevant to the study. Human learning is mediated through cultural tools, including language, symbols, artefacts, and socially established practices. In the present study, the indigenous brewing and distillation processes, local terminology, materials, technological devices, and explanations provided cultural and material resources through which scientific concepts could be discussed and interpreted. Digital devices such as mobile phones and video cameras also functioned as mediational tools, enabling participants to record, display, and revisit aspects of indigenous processes.

The Zone of Proximal Development (ZPD) further provides a useful lens for interpreting the participants' learning. The ZPD refers to the difference between what a learner can accomplish independently and what they can accomplish with guidance or collaboration from more knowledgeable others (Vygotsky, 1978). In this study, indigenous practitioners, peers, tutors, and other knowledgeable participants served as potential sources of guidance for pre-service teachers as they interpreted the scientific meanings embedded in community practices. The movement between indigenous explanations, peer discussion, and formal scientific concepts created opportunities for participants to extend their existing understanding through socially mediated activity.

The socio-cultural framework therefore provides a basis for understanding why competencies such as communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy became visible during the activities. These competencies were expressed through participation in socially organised and culturally situated learning experiences. At the same time, the limited evidence of critical thinking and creativity suggests that cultural context alone does not automatically produce higher-order competencies. From a socio-cultural perspective, the nature of the activity, the questions posed, the forms of interaction, and the tools used to mediate learning influence which competencies become visible.

Integrating indigenous knowledge practices into science instruction enhances understanding and student engagement by linking scientific concepts to familiar cultural contexts (Matindike & Ramdhany, 2025). Indigenous real-world experiences promote meaningful and relevant science learning. Cherry Shive (2025) argues that approaches such as place-based learning, storytelling, and reciprocal relationships help address epistemic gaps while advancing cultural sustainability and justice. Molise (2025) further advocates integrating indigenous knowledge practices into science and economics education, noting that indigenous processes and materials embody systematic and verifiable knowledge that complements Western scientific frameworks. Collectively, these studies demonstrate that indigenous knowledge practices are robust knowledge systems that strengthen the relevance, inclusivity, and comprehension of scientific concepts.

The framework consequently guided the interpretation of Indigenous Knowledge Practices not simply as examples of local culture but as culturally situated resources that can mediate science learning. It also provides a basis for examining how pedagogical structures determine whether engagement with IKPs results primarily in observation and communication or extends to analysis, problem-solving, creativity, and independent application. Importantly, references to culturally familiar or lived experiences in this study relate primarily to the pre-service teachers and the community contexts in which the selected IKPs are practiced; they do not imply that Basic 4 pupils participated in or routinely experienced *pito* brewing or *akpeteshie* distillation as part of their classroom learning. The framework therefore assumes that the competencies observed in the study were

influenced not only by the cultural content of the IKPs but also by the social organisation of the learning activities, the degree of guidance provided and the cultural and digital tools available to participants.

Methodology

The study employed a qualitative exploratory research design to examine how integrating Indigenous Knowledge Practices into science education supports the development of pre-service teachers' core competencies. The design was grounded in culturally responsive and decolonising methodologies that value community-based inquiry and indigenous ways of knowing related to *pito* brewing and *akpeteshie* distillation (Jordan & Hall, 2025; Boardsworth et al., 2024).

The study was conducted at a College of Education in Ghana, purposively selected for its location in a community where these practices are common. This context aligned with Vygotsky's socio-cultural theory, which emphasises learning through environmental interaction and social engagement (Vygotsky, 1978). The study population comprised 312 third-year pre-service teachers enrolled in a B.Ed. Primary Education programme at a College of Education affiliated with the University of Cape Coast, where General Chemistry is offered.

Purposive sampling was used to select 15 pre-service teachers for the qualitative study. The 15 participants were undertaking Supported Teaching in Schools (STS) in 15 different Basic 4 classrooms located in 15 primary schools. They were selected because the Basic 4 science curriculum includes content on the separation of mixtures, which provides a curricular connection to the scientific processes associated with the selected IKPs. The inclusion criteria were that participants be third-year pre-service teachers enrolled in the B.Ed. Programme. Primary Education programme, undertaking Supported Teaching in Schools during the study period, and willing to participate in both the IKP-related learning activities and the research interviews and observations.

Learning activities involved interaction with locally sourced materials, field visits to *pito* brewing and *akpeteshie* distillation sites, use of video recordings, and guided discussions incorporating local terminology to explain scientific concepts. The pre-service teachers interacted with indigenous practitioners and documented relevant aspects of the brewing and distillation processes. The resulting observations, photographs and video materials were subsequently incorporated into the science lessons. Thus, the field visits were not treated as direct evidence of classroom learning; rather, they provided culturally situated resources that the pre-service teachers used to contextualise subsequent classroom activities.

Data were collected using a non-participatory observation guide adapted to the study context and a semi-structured interview guide. Non-participant observation enabled the collection of authentic data from natural settings (Cohen et al., 2018; Creswell & Creswell, 2018), with a focus on predefined behaviours related to core competencies. The unit of observation was the participating pre-service teacher during the field trip and classroom interaction. The researcher used non-participant observation to document how each pre-service teacher interacted with peers during group work, used digital resources, and communicated scientific ideas. The observation therefore focused primarily on evidence of the pre-service teachers' competencies displayed that became visible during interactions.

The interview guide structured the sessions and facilitated in-depth exploration of competency development during the integration of Indigenous Knowledge Practices. All 15 pre-service teachers who participated in the study took part in individual semi-structured interviews. The interviews explored participants' perceptions of the learning activities and the competencies they demonstrated. With participants' consent, the interviews were audio-recorded and transcribed verbatim for analysis.

Interview evidence was triangulated with field observation data to provide a more comprehensive account of the competencies demonstrated during the IKP-based activities.

All 15 pre-service teachers (P1–P15) participated in the semi-structured individual interviews. Each interview was conducted separately, audio-recorded with participants' permission, and transcribed verbatim. During analysis, responses from all 15 participants were considered in identifying categories and themes. In the Results section, quotations are presented selectively as representative evidence rather than as quotations from every participant. Participant codes (P1–P15) are used to protect confidentiality. When a theme was expressed by multiple participants, the number of participants contributing to the theme was reported, and illustrative quotations from selected participants were provided as evidence.

With participant confidentiality and pseudonymisation, each of the fifteen pre-service teachers was assigned a unique identification code ranging from P1 to P15 to maintain confidentiality. The interview and observational evidence were transcribed, analysed and reported using these codes. No participant names or other personally identifiable information are included in the manuscript. In the findings, quotations and descriptions of participant experiences are consistently presented using the assigned participant codes. Before data collection, all participants provided informed consent and were informed that participation was voluntary and that they could withdraw from the study without penalty. The observation and interview data allowed the researchers to identify the nature of learning activities and observable behaviours that could reasonably be interpreted as manifestations of particular competencies in those activities. However, these instruments did not provide sufficient evidence to conduct a systematic evaluation of instructional design. The observed activities provided limited opportunities to demonstrate higher-order competencies.

Trustworthiness was enhanced through triangulation of individual semi-structured interview data and non-participant observation records. Interview recordings were transcribed verbatim, and observational notes were reviewed alongside interview accounts to identify convergence and divergence in the evidence. Participant codes P1–P15 were used throughout the analysis and reporting. All participants provided written informed consent and were informed that participation was voluntary and that they could withdraw without penalty. No participant names or other personally identifying information are reported.

The interview transcripts and observation notes were analysed thematically. Analysis proceeded through familiarisation with the dataset, generation of initial codes, development of categories, construction of candidate themes, review and refinement of themes, and interpretation in relation to the research question and theoretical framework. Both deductive and inductive attention informed the coding process. The six competency domains identified in Ghana's Standards-Based Curriculum provided an initial organising framework, while additional codes were allowed to emerge from participants' accounts and observed activities. NVivo 2020 was used to organise the dataset, manage codes, retrieve coded excerpts, and support systematic comparison across participants and data sources. NVivo was therefore used as a data-management and coding tool rather than as a substitute for researcher interpretation.

Results and Discussions

The findings are based on evidence from all 15 pre-service teachers (P1–P15). Each participant completed an individual semi-structured interview, and interview evidence was considered alongside non-participant observation records. The number of participants reported under each theme refers to participants whose interview responses contained explicit evidence relevant to that theme; it does not indicate the number of participants interviewed. Thus, all 15 participants contributed to the interview

dataset, although the extent to which individual participants discussed particular competencies varied across themes. Direct quotations are identified by participant code, while statements that synthesise responses across participants are presented as thematic interpretations.

However, not every participant expressed views relating to every competency; consequently, the number reported for a particular theme represents only those participants whose responses contained explicit evidence relevant to that theme. Direct quotations are attributed to individual participant codes, while thematic summaries represent patterns identified across the interview dataset. This approach preserves participant confidentiality while making each participant's contribution to the findings transparent.

Scientific knowledge exists within the confines of a socio-cultural world order. Indigenous knowledge practices are valuable resources for educating learners responsibly and for developing relationships within and across communities (Honwad, 2018). The use of relevant community practices, grounded in scientific principles, as examples facilitates learners' understanding of new concepts and the development of core competencies. The community-based encounters were intended to expose pre-service teachers to the cultural and scientific dimensions of the selected IKPs and to support their consideration of how these practices could be pedagogically represented in Basic 4 science. The Basic 4 pupils were not involved in brewing or distillation activities. Rather, the practices were translated into age-appropriate classroom representations, discussions, demonstrations, images, videos, and other learning resources. The core competencies described here are a set of interrelated fundamental abilities that pre-service teachers demonstrate during learning activities. Core competencies were evident during the study and are discussed below.

Communication and Collaboration

Communication and collaboration were evident in the ways pre-service teachers demonstrated knowledge of the scientific processes involved in *pito* brewing and *akpeteshie* distillation**.** Through classroom interactions (group and whole-class discussions), the pre-service teachers used verbal language, symbols, and texts to exchange information about concepts. To listen to and learn from other pre-service teachers, they engaged in conversation. Moreover, they valued, tolerated, and respected their peers' views.

During discussions of distillation, the pre-service teachers shared observations about the heating process, movement of vapour and condensation in the cooling system. Observation notes indicated that participants exchanged explanations, compared interpretations, and contributed to group discussions, inviting different explanations and encouraging pre-service teachers to compare their observations with concepts previously encountered in science lessons.

For example, during a group activity on separation of mixtures, pre-service teachers were asked to identify three local devices used in the distillation process and match them with corresponding laboratory apparatus. Observation notes showed that members of the groups explained their choices to one another, questioned alternative interpretations, and collectively agreed on the responses before presenting their conclusions to the class. In one group, a participant explained the separation process in terms of differences in boiling points, while another questioned whether this explanation adequately represented the indigenous distillation process. The group discussed the alternative explanations and reached a shared interpretation before presenting it. These observations demonstrate communication through explanation, questioning, and the exchange of scientific ideas, and collaboration through the negotiation of meaning, joint decision-making, and the collective completion of the task.

During one group activity, pre-service teachers compared their interpretations of the separation processes observed in *pito* brewing and *akpeteshie* distillation. One participant explained the scientific process using the concept of differences in boiling points, while another questioned whether the same explanation applied to the indigenous process under discussion. The group subsequently discussed the explanation and jointly presented their interpretation to the class. This interaction provided evidence of communication through explanation and questioning, and collaboration through the negotiation of meanings and joint presentation of conclusions.

The observational evidence, therefore, indicates that communication and collaboration were not treated simply as social interaction. They were manifested through pre-service teachers' exchange of scientific observations, peer explanation, negotiation of meaning, and joint completion of learning tasks. These practices are consistent with the socio-cultural perspective underpinning the study, in which learning develops through interaction and the mediation of knowledge through social activity. They also align with NaCCA's (2019) emphasis on communicating ideas, collaborating with others and using interaction to advance learning.

The core competencies exhibited by the pre-service teachers aligned well with the NaCCA (2019) reforms, which state that learners learn to collaborate and communicate ideas, express their individuality, advance their learning, and accomplish tasks through co-operation. Through communication and collaboration, they acquire, develop, and transform ideas and information. They establish connections with other pre-service teachers (British Columbia Ministry of Education, 2015). Finding fulfilment, purpose, and joy all depends on having strong communication and collaboration skills. The findings of the current study align with the benefits of collaborative learning expressed by Babalola (2024), Schmidt et al. (2023), and Laal and Ghodsi (2012).

Thus, the findings are consistent with Vygotsky's socio-cultural perspective, which positions social interaction and mediated activity as important processes through which knowledge is constructed. In the present study, communication and collaboration were therefore not treated merely as social behaviours; they functioned as mechanisms through which pre-service teachers exchanged observations, negotiated meanings and collectively interpreted scientific ideas embedded in culturally familiar practices.

Cultural Identity and Global Citizenship

Global citizenship involves developing learners' sense of responsibility toward societal and national development. This competency was evident among pre-service teachers during field visits to indigenous practice sites, where they engaged directly with local practitioners. These experiences provided opportunities for their understanding of the social and economic dimensions of Indigenous Knowledge Practices (IKPs) and enabled them to demonstrated evidence of knowledge, skills, and attitudes to community development. In some instances, pre-service teachers advised practitioners on improving production quality to advance their economic standing. Such engagement equipped them with competencies relevant to national and global socioeconomic participation. These findings support Mudzamiri's (2019) assertion that indigenous artefacts enhance learning by aligning instruction with cultural contexts, promoting decolonised pedagogy, and supporting meaningful learning and cultural sustainability.

Interview evidence provided further support for the emergence of cultural identity and global citizenship. One participant, P4, reflected that "*Ideas from two different cultures were involved in the integration process, and this made the lesson interesting.*" This response suggests that the participant recognised an interaction between indigenous knowledge and formal scientific knowledge rather than viewing the two knowledge systems as completely separate. The participant's response also indicates

that integrating local practices created an opportunity to reconsider the relationship between culturally situated knowledge and school science.

This interpretation is consistent with the socio-cultural framework of the study because learning occurred through interaction with community-based knowledge, local practitioners and culturally familiar practices. The finding also supports scholarship emphasising the value of Indigenous Knowledge Systems in making science education culturally relevant and responsive (Mudzamiri, 2019; Wilujeng & Prasetyo, 2018). In this sense, cultural identity was demonstrated not merely through familiarity with *pito* brewing or *akpeteshie* distillation, but through participants' recognition of the knowledge and expertise embedded in these practices.

Generally, these findings can be interpreted through Vygotsky's socio-cultural theory, as participants' understanding was evident in their interactions with community practitioners, culturally familiar practices, peers, and formal scientific concepts. The indigenous practices functioned as cultural resources through which participants negotiated meanings between community knowledge and school science. This interpretation is consistent with scholars emphasising culturally responsive and contextually relevant science education (Mudzamiri, 2019; Wilujeng & Prasetyo, 2018).

Personal Development and Leadership Role

The evident personal development and leadership enabled pre-service teachers to distinguish between right and wrong through reflection on past errors and failures. Constructive feedback from peers and the researcher supported learning and fostered the ability to assist others effectively. Participants demonstrated values such as honesty, empathy, and selflessness, as well as increased persistence, resilience, and confidence. These competencies reflect the NaCCA's (2019) assertion that well-developed critical thinking and problem-solving skills enable learners to analyse situations and make informed decisions based on experience. Learners are therefore encouraged to confront challenges and take responsibility for their learning. Consistent with the British Columbia Ministry of Education (2015), pre-service teachers also demonstrated the ability to transfer knowledge across subject areas through critical thinking. This corroborates evidence that personal development and leadership can develop through active, collaborative and interdisciplinary learning rather than through explicit leadership instruction or the mere occupation of formal leadership positions (Ermak, 2025; Uaikhanova et al., 2022).

Digital Literacy

Developing digital literacy among the pre-service teachers was not so much of a challenge. Digital literacy was evidenced primarily through participants' purposeful use of mobile phones, videos, and other digital resources to access, record, display, and communicate information related to the IKPs. Device ownership alone was not treated as evidence of digital literacy. They were thus able to download videos and pictures shared on their platforms and complete assigned activities. Some utilising this digital and technological device to communicate, learn, and discover. They realised that instead of their phones just being used for entertainment, they could also more appropriately use them as educational tools. The few who did not have smartphones to be connected to the internet were not left out. Videos and pictures were projected during the lesson for all to see. Several studies (Javid et al., 2023; Wang et al., 2022; Imwa, 2020) have highlighted the benefits of using smartphones for knowledge and skill acquisition in teaching various subjects. This is supported by NaCCA (2019) and Admiraal et al. (2017), who state that learners are equipped with fundamental background knowledge and skills to utilise digital media appropriately in their learning. Although opposition to the use of smartphones by students has also been expressed (Aloteibi et al., 2024).

Competencies that did not Emerge Strongly: Critical Thinking and Problem-Solving, and Creativity and Innovation

The available evidence did not demonstrate strong evidence of critical thinking, problem-solving, or creativity and innovation in the observed activities, despite the importance of these competencies in Ghana's standards-based science curriculum. This finding should not be interpreted to mean that Indigenous Knowledge Practices lack the capacity to support higher-order competencies. Rather, the observed activities provided limited opportunities for pre-service teachers to formulate hypotheses, analyse evidence, evaluate alternative explanations, solve open-ended problems or generate new solutions. Because this was an exploratory qualitative study, the absence of strong evidence should not be interpreted as proof that the participants lacked these competencies. Rather, it indicates that the observed activities did not provide sufficient opportunities for these competencies to become visible in the collected data

The finding suggests that the pedagogical framing of an Indigenous Knowledge Practice is important in determining the competencies that become visible during instruction. In the present study, several activities were primarily descriptive, focusing on observing and documenting indigenous processes. Consequently, communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy were more readily observable than higher-order cognitive competencies. When IKPs are deliberately combined with inquiry-based questions, experimentation, problem-solving tasks, and opportunities for pre-service teachers to design or evaluate solutions, they may provide richer opportunities to develop critical thinking and creativity. Further research is therefore required to examine how specific pedagogical structures can transform culturally situated IKPs into more inquiry-oriented learning experiences.

Pre-Service Teachers' Views on Demonstrated Evidence of Competencies

Examples of the pre-service teachers' views captured on the competencies they thought they were evident during the teaching and learning process of the study were depicted by the statements presented below, according to themes and the number of participants whose interview responses contained explicit evidence related to each theme. Direct quotations from the semi-structured interviews are presented in quotation marks and attributed to the relevant participant code (P1–P15). Paraphrases and thematic summaries are not presented as direct quotations and are clearly identified as the researchers' interpretations of the interview and observation data. The accompanying explanatory paragraphs are the researchers' thematic interpretations of the interview and observation data. The number reported for each theme represents the number of participants whose interview accounts contained explicit evidence relevant to that theme. The following italicised statements are verbatim excerpts from the semi-structured interviews with the pre-service teachers. Participant codes identify the source of each quotation. Interpretive statements that follow the quotations are the researchers' thematic interpretations and are not direct participant statements.

a. Theme: Cultural Identity and Global Citizenship (10 participants)

Interview evidence provided further support for the emergence of cultural identity and global citizenship thus:

P1: "I enjoy palm nut soup a lot, but I never knew there is more to the palm tree." "I found it difficult pronouncing the word akpeteshie."

P3: "There are a lot of activities within the communities but the problem is how to deduce scientific concepts from them".

P4: "These trees are not found in my home region, in the north but I can use pito in teaching"

P5: "I know of pito and akpeteshie, but I have never related akpeteshie with distillation as the scientific process involved in producing it. The whole concept is interesting".

P6: "I see people in my community sell pito and akpeteshie but never "had never connected akpeteshie production with distillation as the scientific process in classroom learning"

P7: "It is difficult to identify the scientific concepts in indigenous knowledge practices".

P10: "To be frank, I see people produce akpeteshie and the scientific concepts were already known to me".

P11: "The students will refer to me as a palm wine tapper"

P14: "I like the way two cultures are blending in teaching but it wasn't easy. I had to go back to watch videos of pito brewers over and over again for further clarification"

P15: "Pito is business for people from the north and Akpeteshie is business for people from the south." "In my hometown, the waste from is used to feed pigs." "Ideas from two different cultures were involved in the integration process, and this made the lesson interesting".

These quotes capture the moment when pre-service teachers recognised the coexistence of indigenous and scientific epistemologies. The participant's reference to "two different cultures" suggests awareness that science is not detached from culture; rather, it intersects with local knowledge systems. The comment signals increased respect for traditional brewing and distillation methods, which rely on systematic observation and tacit scientific reasoning. The pre-service teachers' interest indicated that culturally relevant pedagogy strengthened engagement and built pride in local knowledge systems while still supporting scientific understanding. The integration of Indigenous knowledge practices provided a powerful avenue for developing cultural identity and global citizenship. Pre-service teachers expressed a deepened appreciation for traditional knowledge systems, particularly the expertise of local brewers and distillers who rely on empirical experimentation to achieve consistency, purity, and safety in their products. Participants' accounts suggest that some pre-service teachers began to view themselves as potential mediators between community-based knowledge and formal science teaching. Indigenous practices contain systematically developed empirical knowledge that can provide culturally meaningful entry points for discussing scientific concepts.

These responses provide evidence of cultural awareness and recognition of the relationship between indigenous and formal scientific knowledge. They may be interpreted as aspects of cultural identity and as potential foundations for global citizenship, although the study did not directly assess global citizenship behaviours. Through the Indigenous knowledge practice activities, pre-service teachers began to see themselves as cultural mediators who could bridge indigenous knowledge and formal science in ways that honour local traditions while preparing pre-service teachers for global scientific discourse. The fusion of scientific concepts and IKPs shows that the competency evident here is not simply cultural appreciation, it is the ability to situate scientific learning within broader cultural and global contexts.

These responses suggest that the participant recognised an interaction between indigenous knowledge and formal scientific knowledge rather than viewing the two knowledge systems as completely separate. The participant's response also indicates that the integration of local practices created an opportunity to reconsider the relationship between culturally situated knowledge and school science.

This interpretation is consistent with the socio-cultural framework of the study because learning occurred through interaction with community-based knowledge, local practitioners, and culturally familiar practices. The finding also supports scholarship emphasising the value of Indigenous Knowledge Systems in making science education culturally relevant and responsive (Mudzamiri, 2019; Wilujeng & Prasetyo, 2018). In this sense, cultural identity was demonstrated not merely through familiarity with *pito* brewing or *akpeteshie* distillation, but through participants' recognition of the knowledge and expertise embedded in these practices.

b. Theme: Digital Literacy (15 participants)

Interview evidence further supported the emergence of digital literacy.

P1: "My phone battery is weak, and did not last for the session'

P2: "I watched videos before the group interaction"

P3: "I tried using my phone to play videos and display pictures, but I could not"

P4: "My phone was even sent round for group members to have a closer view of what was displayed." It was exciting.

P5: "It is not easy to buy data, but on campus I had free access to data".

P6: "recorded scenes were not clear" "The use of a computer to play the videos helped me a lot. It made the class quiet as all learners were glued to the device"

P7: "No phone oooh, my is spoilt had to rely on group members"

P8: "Easy to watch videos and pictures but not easy to link it to science"

P9: "I simply download the information I needed from the internet".

P10: "I just imagined what would happen if it fell, fortunately, I handled it with care".

P11: "My phone is not a good one, I had to rely on group members for videos and pictures".

P12: "Lesson is interesting I had access to data"

P13: "The network is weak, difficult to download videos"

P14: "Interesting but not applicable to the school I will be teaching when I complete school"

P15: "Lesson is interesting with the use of ICT"

The comments highlight more than classroom management. It showed the pre-service teacher's developing ability to use digital tools to enhance scientific understanding. Videos of brewing stages or distillation apparatus allowed pre-service teachers to repeatedly observe processes like bubbling during fermentation or condensation in the cooling coil. The attention captured ("glued to the device") implies focused scientific observation. The evidence demonstrates the functional use of digital tools to access, display, record, and communicate learning resources. However, the data do not permit a comprehensive assessment of participants' digital literacy proficiency. Evidence consistent with aspects of digital literacy was observed through the use of mobile phones, digital cameras, and video-editing tools to record, organise, and present the stages of *pito* brewing and *akpeteshie* distillation. Pre-service teachers used digital tools as a pedagogical competency. They demonstrated and used available digital resources to access, display, communicate, and discuss information related to the IKPs.

Digital literacy thus emerged as a science-supporting competency. The use of digital tools enabled pre-service teachers to slow down, review, and analyse scientific phenomena that might otherwise be overlooked in real time. This aligns with the goal of competency-based science education, where technology enhances inquiry and observational accuracy.

c. Theme: Personal Development and Leadership Role (8 participants)

Eight of the fifteen participants (P1–P8) provided interview responses that explicitly indicated personal development or leadership-related experiences. Interview evidence provided further support for the emergence of personal development and leadership roles;

P1: "This is an eye-opener, I never thought of such a thing. It is good, at least I have learnt how to use local materials."

P2: "It is good for classroom delivery but requires a lot of preparation". "Embarking on the field trip made me learn a lot from the indigenous practitioners".

P3: "I feel delighted taking part in the study but it is not an easy matter as I see it, especially getting the materials and even coming up with the scientific concepts".

P4: "The practical application of the indigenous knowledge practices in class is interesting. It is like bringing the home environment to the classroom".

P5: "As a pre-service teacher, I am challenged to develop practical ways that can attract learners towards the learning of science".

P6: "Yes, integration of indigenous knowledge practice is real and I can testify to it".

P7: "I was very excited going out for the first time to observe indigenous practitioners at work"

P8: "I could connect what they were doing to learning in the classroom. The issue however is whether these practices will be available everywhere and all the time".

These reflections show that personal development occurred through authentic engagement with community experts. The statement revealed humility and openness - traits associated with reflective professional growth. Participants' accounts suggested that observing indigenous practitioners enabled them to recognise systematic processes involving temperature regulation, fermentation, and distillation. The willingness to learn from them indicated growth in leadership disposition: recognising expertise, asking questions, and guiding peers during the learning experience. These behaviours demonstrate that leadership was expressed through scientific interpretation, initiative, and confidence-building. Personal development and leadership were evident in instances where pre-service teachers took the initiative to explain scientific concepts embedded in indigenous knowledge practices. During observations at the brewing and distillation sites, clarifying how fermentation produces carbon dioxide or how distillation separates alcohol from impurities.

These leadership behaviours were evident in the increased confidence demonstrated through recognising science in familiar cultural practices. Pre-service teachers who typically remained quiet in formal classroom settings participated actively during indigenous knowledge practices-based lessons, indicating that culturally grounded science instruction can enhance pre-service teachers' self-efficacy. Leadership in this context was therefore intertwined with scientific reasoning. Participants' reflections indicated increased confidence in connecting familiar community practices with scientific concepts such as fermentation, evaporation, condensation, and separation of mixtures.

The evidence provides indications of leadership-related dispositions, particularly initiative, responsibility and willingness to guide peers; however, the study did not employ a dedicated leadership assessment, and these findings should therefore be interpreted as evidence of leadership-related behaviours rather than as a comprehensive measure of leadership competency.

d. Theme: Communication and Collaboration (15 participants)

Interview evidence provided further support for the emergence of communication and collaboration were:

P1: "You know what? My learners in groups were enthused with the task assigned to them".

"It amazes me to see how indigenous materials and activities can be used as substitutes for scientific apparatus and processes"

P2: "It is good to see indigenous activities infused into teaching and learning".

P3: "In fact, my understanding of the term 'indigenous knowledge practices' has changed. It is about the practices and activities within our communities".

P4: "Indigenous knowledge practices are about the environment and the activities of the local people."

P5: "I lived in a community where pito brewing is a predominant occupation for women. These women take turns to brew and sell on market days".

P6: "It is more about bringing the activities of the community or environment to the classroom."

P7: "Indigenous knowledge practices are the activities we grew up to find useful within the communities".

P8: "Indigenous knowledge practices are the practices and ideologies of the community which can be used in the classroom for teaching and learning".

P9: "I wish the topics in the curriculum were listed with their corresponding indigenous knowledge practices. That could have made the integration easier".

P10: "I have learnt a lot from this process.

P11: "At least I can integrate some local content into my teaching (macro-teaching/off campus teaching practice) now".

P12: "I didn't see the process as challenging".

P13: "From the field exploration, I gathered a lot of information which will guide my lesson notes preparation and the classroom presentation to be more interactive".

P14: "Exploring the community serves as the key to this integration, but it requires careful and critical observation to sieve out the science concepts".

P15:"Science is really within the community but the problem is how to get it". "Not until this study I did not know these practices could be integrated into teaching"

These responses illustrated how culturally grounded scientific activities create natural social engagement. The enthusiasm of pre-service teachers revealed that the indigenous knowledge practices - based task - likely involving observing fermentation stages or discussing distillation apparatus - sparked curiosity and interaction. Such engagement aligns with Vygotsky's notion that learning is mediated through social activity, showing that communication in this context was central to co-constructing scientific meaning.

This quote demonstrates a shift in the pre-service teacher's beliefs about knowledge sharing. Allowing pre-service teachers to handle the device signifies a growing willingness to use personal resources to support collaborative scientific learning. The excitement expressed by pre-service teachers indicated emotional engagement - an important component of effective scientific communication.

This reflection showed that collaborative work was not incidental but fundamental to meaning-making. Through group activities, pre-service teachers engaged in negotiating understanding of scientific processes such as boiling points, evaporation, mixture separation, and temperature regulation, demonstrating that collaboration provided opportunities to understand indigenous knowledge practices and related scientific principles. Communication and collaboration emerged strongly across all indigenous knowledge practices and were integrated into activities. Pre-service teachers engaged in group discussions to interpret the scientific processes involved in *pito* brewing and *akpeteshie* distillation. These discussions included sharing observations about fermentation stages, explaining why temperature control is critical for yeast activity, and clarifying the roles of still components such as the condenser and cooling coil.

The integration of indigenous knowledge practices created a shared cultural and scientific context that made communication more meaningful. Because the processes were familiar to many pre-service teachers, they were more comfortable articulating their scientific reasoning. Collaboration occurred naturally as pre-service teachers worked in groups to document brewing and distillation stages, cross-check observations, and compare traditional explanations with scientific concepts taught in their coursework. These interactions demonstrate that communication and collaboration competencies were not merely social. Rather, they were essential mechanisms for collectively constructing scientific understanding through culturally grounded practices.

The findings can be interpreted through Vygotsky's socio-cultural perspective, particularly the proposition that learning is mediated through social interaction and culturally situated tools. The indigenous practices served as cultural resources through which pre-service teachers connected scientific concepts with familiar community experiences. Interaction with peers and indigenous practitioners therefore provided opportunities for participants to negotiate meanings, compare explanations, and reinterpret local practices using formal scientific concepts. This supports the argument that knowledge construction is not an exclusively individual process but is shaped by the social and cultural contexts in which learning occurs (Vygotsky, 1978).

The finding also extends the literature on Indigenous Knowledge Practices in science education. Rather than treating IKPs merely as examples to illustrate scientific concepts, the activities provided a context in which participants could engage with local knowledge holders and consider the relationship between indigenous and formal scientific knowledge systems. This interpretation is consistent with studies advocating culturally responsive and contextually relevant approaches to science teaching (Mudzamiri, 2019; Wilujeng & Prasetyo, 2018).

Two competencies - Critical Thinking and Problem-Solving, and Creativity and Innovation - did not emerge clearly in the data. Their absence provides important insight into how IKP-based lessons may need to be deliberately structured to offer opportunities for competency-based learning goals.

Conclusion

This study examined how integrating Indigenous Knowledge Practices (IKPs) into science lessons provided pre-service teachers with opportunities to demonstrate selected core competencies during Supported Teaching in Schools in Ghana. The findings indicate that IKP-based science activities provided culturally relevant contexts for science learning and created opportunities for pre-service teachers to demonstrate selected core competencies by connecting classroom concepts with familiar

community practices and experiences. It also created opportunities for learners to demonstrate competencies such as communication and collaboration, cultural identity and global citizenship, personal development and leadership, and digital literacy.

However, the findings do not suggest that integrating IKPs alone leads to the comprehensive development of all core competencies. In particular, evidence of higher-order competencies, including critical thinking, problem-solving, creativity, and innovation, was comparatively limited. This suggests that the educational value of IKPs depends not simply on their inclusion as lesson content but on how teachers structure learning activities around them.

Teacher educators should deliberately structure IKP-based activities around higher-order questions that require pre-service teachers to formulate hypotheses, analyse evidence, compare alternative explanations, solve authentic problems, and generate or evaluate solutions.

Curriculum developers should provide guidance on how appropriate Indigenous Knowledge Practices can be mapped onto specific curriculum topics and core competencies while maintaining age-appropriateness, ethical considerations, and safety.

Pre-service teachers should be supported to distinguish between using an IKP as a contextual illustration and designing an inquiry-oriented learning experience in which the IKP becomes the basis for investigation, analysis, and problem-solving.

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