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Revitalizing geometry education: The role of indigenous pedagogies in Kalomo district's secondary schools

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Abstract

Mainstream education often marginalizes the cultural heritage and indigenous knowledge systems of local communities, particularly in mathematics instruction. This study investigates the integration of indigenous pedagogies into geometry education to enhance student engagement and cultural responsiveness. Grounded in a critical constructivist paradigm, the study recognizes knowledge as co-constructed through learners' cultural experiences and emphasizes the transformative potential of indigenous worldviews in shaping mathematical understanding. It employs a qualitative case study design to explore how traditional knowledge impacts student performance and the challenges faced in its incorporation. Data were collected from teachers, administrators, community elders, and students through interviews, focus groups, and classroom observations. Findings through thematic analysis revealed that indigenous pedagogies, such as traditional geometric patterns and community involvement, enhance student engagement, cultural pride, and geometry performance. Moreover, students demonstrated improved conceptual understanding and enthusiasm when learning activities reflected their cultural contexts. However, challenges include resource limitations, curriculum rigidity, and insufficient professional development. The study recommends creating resources tailored to indigenous pedagogies, greater curricular flexibility, and enhanced administrative support. It concludes by emphasizing the long-term value of integrating indigenous knowledge in mathematics education, not only to improve learning outcomes but also to contribute to cultural sustainability and educational equity in Zambia.

Keywords: Culturally Responsive Education, Geometry, Indigenous Pedagogies, Secondary School, Teaching Mathematics

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Mathematics education, particularly in post-colonial contexts, has long been dominated by Western pedagogical paradigms that often marginalize indigenous knowledge systems and ways of learning. This dominance has led to a disconnect between classroom instruction and the lived realities of learners in culturally diverse settings. In Zambia, especially in rural districts like Kalomo, this gap continues to affect learner engagement, comprehension, and cultural identity. While there is growing recognition of the need to integrate indigenous pedagogies into the curriculum, existing research has largely remained theoretical, with limited empirical studies that explore the practical implementation of such approaches in teaching specific mathematical content areas like geometry.

This study is grounded in the theoretical lens of critical pedagogy, developed by Paulo Freire in 1967, which positions education as a means of social transformation. Critical pedagogy critiques traditional, teacher-centered models and advocates for dialogical, student-centered learning that values learners' socio-cultural experiences. In this framework, students are viewed as active participants in the construction of knowledge rather than passive recipients. The relevance of this theory lies in its emphasis on contextualizing learning in a way that resonates with students' cultural backgrounds and daily lives.

By using critical pedagogy as a guiding framework, this study situates indigenous knowledge systems as valid and transformative tools for mathematics instruction. Indigenous practices-such as geometric patterns in craftwork, land measurement in agriculture, and spatial reasoning in architecture-offer culturally grounded entry points for understanding mathematical concepts. This theoretical approach enables an exploration of how local epistemologies can challenge and enrich the Eurocentric nature of the current geometry curriculum, making it more inclusive and empowering for both teachers and students.

Against this backdrop, the study investigates the integration of indigenous pedagogical methods in the teaching of geometry in selected secondary schools in Kalomo District. It explores how these culturally responsive approaches affect student engagement, conceptual understanding, and academic performance, while also examining the practical challenges faced by educators attempting to merge indigenous practices with formal curriculum expectations. Informed by critical pedagogy, the study frames these challenges not merely as logistical barriers but as reflections of broader systemic tensions between standardized education and community-rooted knowledge.

This research, therefore, contributes to the ongoing discourse on decolonizing mathematics education and aligning instructional strategies with students' cultural realities. In doing so, it seeks to answer the following research questions:

1. What indigenous pedagogical methods are used to teach geometry in Kalomo District's secondary schools?
2. How does the use of indigenous approaches affect students' performance in geometry?
3. What challenges are encountered when incorporating indigenous approaches into geometry education?

Based on the above background, the literature review focused on integrating Indigenous Knowledge Systems (IKS) within the context of education, specifically in mathematics and geometry. The review explored how traditional knowledge, and practices had the potential to enhance learning experiences, improve academic performance, and address challenges related to incorporating indigenous methods into formal education. To record the existing solutions and to show which is the best of previous research, and to show the scientific merits or novelties of this study, a short literature survey was carried out under the following themes.

Indigenous Knowledge Systems in Education

Indigenous Knowledge Systems (IKS) in education, particularly within African contexts, encompass traditional knowledge and practices that are deeply embedded in the cultural, social, and ecological realities of indigenous communities. IKS offers a holistic worldview that integrates spiritual, ecological, and social dimensions, in sharp contrast to the compartmentalized and reductionist approaches characteristic of many Western education systems. The significance of IKS lies in its potential to foster inclusive and culturally responsive educational frameworks that value and incorporate local knowledge,

thereby challenging the longstanding dominance of Eurocentric epistemologies in African education (Lukong, 2020; Nnama-Okechukwu & McLaughlin, 2022; Mutekwe, 2015).

IKS serves as a cornerstone of community identity and resilience across many African societies. Dei (2013) highlights the importance of understanding indigenous philosophies through the society–nature–culture nexus, which emphasizes the interdependence of these elements in sustaining indigenous ways of life. This perspective is critical for designing contextually relevant curricula that empower learners to critically engage with their cultural heritage. Integrating IKS into educational frameworks helps counteract the negative perceptions that African students may develop toward their own cultural knowledge when their schooling is dominated by Western paradigms (Fankah-Arthur & Weber-Pillwax, 2020; Mawere, 2015).

Importantly, the incorporation of IKS into education transcends cultural preservation; it is also a central component of the decolonization of knowledge. Colonial legacies often marginalized indigenous knowledge systems, labeling them as primitive or unscientific (Matemba, 2020). Contemporary scholarship on decolonization emphasizes the need for a balanced approach that acknowledges the epistemic value of indigenous knowledge alongside Western scientific paradigms (Seehawer, 2018; Nxumalo & Mncube, 2018; Koopman, 2018). Such a dual framework enriches the educational experience, equipping students to navigate a pluralistic world in which multiple knowledge systems coexist and interact.

The pedagogical implications of integrating IKS are considerable. Kgope (2023) argues that policies promoting IKS in higher education create spaces for indigenous practitioners to engage meaningfully in academic discourse. These participatory approaches not only validate indigenous epistemologies but also increase the relevance of education to local communities. Furthermore, employing indigenous proverbs, oral traditions, and storytelling as pedagogical tools fosters lifelong learning and strengthens students' cultural connections (Avoseh, 2012).

Overall, the integration of IKS into African education is essential for building equitable, culturally responsive learning environments. By valuing and incorporating local knowledge, educational institutions can empower learners to critically interrogate their identities and engage meaningfully with the world around them. Such integration challenges the hegemony of Western epistemologies and promotes a richer, more diverse educational experience that reflects the complexity and vitality of African cultural landscapes.

Indigenous Pedagogical Methods in Mathematics

Indigenous pedagogical approaches to mathematics—particularly in the teaching of geometry—offer a diverse repertoire of culturally relevant strategies that can meaningfully enhance students' learning experiences. Rooted in the cultural practices and epistemologies of indigenous communities, these methods present an alternative framework to conventional Western approaches, foregrounding cultural relevance, contextual learning, and holistic knowledge construction. By leveraging Indigenous Knowledge Systems (IKS), educators can situate geometry instruction within familiar socio-cultural contexts, thereby bridging the gap between abstract mathematical ideas and students lived realities.

One central strategy in indigenous mathematics education is the use of local languages and terminologies to mediate mathematical concepts. Lukmana and Taha (2022) emphasize that teaching mathematics through indigenous languages helps bridge the cognitive gap between formal mathematical discourse and students' cultural frames of reference. This approach not only facilitates comprehension but also affirms the epistemic legitimacy of indigenous knowledge, rendering mathematics more accessible and meaningful. Similarly, Naidoo (2021) contends that embedding culturally grounded activities within mathematics classrooms promotes active engagement and supports students in constructing mathematical knowledge through social interaction and contextually relevant problem-

solving. The connection between culture and geometric concepts is particularly evident in traditional practices such as pattern-making, architecture, and craftwork. Meaney and Evans (2012) argue that indigenous quantifying practices—which frequently involve measurement and spatial reasoning—have been historically neglected in formal mathematics curricula. Integrating these practices into geometry instruction allows educators to ground abstract concepts such as symmetry, proportion, and spatial relationships in tangible cultural experiences. For example, traditional craftwork that involves geometric designs can serve as a concrete entry point for exploring geometric properties, offering students opportunities for hands-on, experiential learning.

In addition, indigenous games have been recognized as powerful pedagogical tools for enhancing students' understanding of geometry. Nabie (2015) notes that culturally grounded games promote collaborative learning by facilitating interaction among students, teachers, and community members, thereby reinforcing mathematical concepts while simultaneously strengthening cultural identity. Dewah and Wyk (2014) further argue that these games foster experiential learning, suggesting that they can effectively support the teaching of geometry in ways that resonate with students' everyday experiences. The integration of indigenous knowledge into geometry education also represents a crucial step toward the decolonization of mathematics curricula. Mudaly (2018a; 2018b) calls for educators to indigenize the mathematics curriculum by recognizing and validating indigenous epistemologies alongside Western mathematical frameworks. This dual recognition enriches students' educational experiences and empowers indigenous learners by affirming their cultural identities and ways of knowing.

In sum, indigenous pedagogical methods offer powerful, culturally responsive strategies for teaching geometry. By incorporating local languages, traditional practices, and community-based activities, educators can cultivate a more inclusive and engaging learning environment. Such approaches deepen students' conceptual understanding, foster stronger connections to their cultural heritage, and contribute to a mathematics curriculum that is both equitable and contextually relevant.

Geometry and Culture in the Context of Kalomo District

The impact of Indigenous pedagogies on student learning outcomes—particularly in mathematics and geometry—has received increasing scholarly attention due to their potential to enhance student engagement, conceptual understanding, and academic performance. These culturally responsive approaches incorporate learners' cultural backgrounds, experiences, and epistemologies into the teaching process, yielding significant cognitive and affective benefits. This section synthesizes empirical evidence demonstrating the positive effects of Indigenous pedagogies in mathematics education.

A growing body of research shows that culturally relevant pedagogies substantially improve student engagement and comprehension. Thorpe and Burgess (2016) argue that adapting curricula to meet students' cognitive, emotional, and cultural needs leads to improved educational outcomes. This claim is supported by Roorda et al.'s (2017) meta-analysis, which found a strong association between positive teacher–student relationships and increased academic achievement. Culturally relevant pedagogical approaches foster emotional connection and motivation, encouraging active participation in mathematical learning. This is particularly significant in geometry, where engagement with spatial reasoning tasks is critical to conceptual development.

Empirical studies further corroborate the effectiveness of Indigenous pedagogies in bridging the gap between formal mathematics education and students' everyday experiences. Madimabe et al. (2022) demonstrate that integrating Indigenous knowledge into the mathematics curriculum—especially in geometry—provides meaningful, contextually grounded learning opportunities. The use of culturally

relevant teaching aids, including traditional crafts, architectural patterns, and games, enables students to explore geometric concepts through hands-on, experiential learning. This approach not only deepens comprehension but also affirms the cultural significance of mathematics.

The creation of culturally safe learning environments is also central to improving academic outcomes. Howlett et al. (2013) emphasize that students' sense of belonging and value within the classroom correlates with greater participation and achievement. This is particularly relevant to the teaching of geometry, where abstract and formalized representations may otherwise appear disconnected from students' realities. Incorporating Indigenous perspectives situates geometric concepts in tangible cultural contexts, thereby reducing cognitive barriers and enhancing comprehension.

Beyond engagement and comprehension, Indigenous pedagogies have been linked to measurable improvements in academic performance. Rosa (2023), through her work on ethnomathematics, argues that connecting mathematical concepts to students' cultural contexts promotes both epistemic justice and higher achievement. When learners perceive mathematics as relevant to their lived experiences, they are more likely to perform successfully in assessments, including those focused on geometry. Similarly, Nesterova (2019) highlights that culturally responsive pedagogies can mitigate systemic educational disadvantages, particularly for Indigenous learners, thereby closing performance gaps. The incorporation of traditional practices such as pattern-making and spatial reasoning into the geometry curriculum not only strengthens conceptual understanding but also affirms cultural identity, further contributing to positive learning outcomes.

Finally, the integration of Indigenous pedagogies into mathematics education—particularly in geometry—provides substantial cognitive, affective, and academic benefits. The empirical literature consistently demonstrates that culturally responsive approaches improve engagement, deepen conceptual comprehension, and enhance performance by linking mathematical learning to students' cultural knowledge and experiences. These findings underscore the necessity of designing inclusive, culturally safe educational environments that acknowledge and legitimize IKS, ultimately contributing to more equitable and effective mathematics education.

Impact of Indigenous Pedagogies on Student Learning Outcomes

The integration of Indigenous pedagogies into educational frameworks has been consistently shown to enhance student learning outcomes, particularly in mathematics. Culturally relevant pedagogies that embed students' cultural contexts and lived experiences within instruction foster higher levels of engagement, deeper comprehension, and improved academic performance. This is especially critical in mathematics education, where conventional teaching approaches often fail to connect meaningfully with the cultural realities of Indigenous learners.

Research has demonstrated that culturally responsive teaching strategies improve the academic success of marginalized students. Kokka (2018) highlights that culturally relevant and responsive pedagogy enhances students' sociopolitical consciousness and supports their overall well-being in mathematics classrooms. Similarly, Leonard et al. (2010) argue that combining culturally relevant instruction with social justice pedagogy motivates students to engage more deeply with mathematics, thereby improving learning outcomes. These findings indicate that students are more likely to actively participate and excel academically when their cultural identities are acknowledged and reflected in the curriculum. Empirical evidence further substantiates the positive impact of Indigenous pedagogies on mathematics achievement. Sianturi et al. (2018) found that a place-based curriculum integrating local culture and environmental knowledge significantly enhanced both teachers' and students' engagement and understanding of

mathematical concepts. This aligns with Abd Jalil and Abdullah (2023) findings, which showed that community involvement and the use of culturally relevant teaching materials increased motivation and engagement among *Orang Asli* students in Malaysia. Together, these studies underscore the potential of Indigenous pedagogies to create more inclusive, contextually grounded, and effective learning environments.

The use of multimodal literacies has also been identified as a powerful vehicle for culturally relevant mathematics instruction. Taylor (2018), in her research on proof in geometry, demonstrates that allowing students to engage with mathematical content through multiple modes of expression—such as visual representations, storytelling, and collaborative dialogue—not only deepens conceptual understanding but also enables learners to integrate their cultural perspectives into mathematical reasoning. This approach resonates with the principles of culturally sustaining pedagogy, which seeks to preserve and affirm cultural identities while advancing academic achievement.

Collectively, the empirical evidence demonstrates that Indigenous pedagogies positively influence student engagement, comprehension, and performance in mathematics. By incorporating culturally relevant materials, community knowledge, and multimodal forms of expression, educators can create learning environments that are both academically rigorous and culturally affirming. Such environments not only improve achievement in mathematics, including geometry, but also promote students' sense of belonging, agency, and empowerment within educational spaces.

METHODS

Research Design

This study employed a qualitative research approach, combining elements of ethnographic and exploratory case study designs to gain a rich, contextualized understanding of how indigenous pedagogical methods are used to teach geometry in Kalomo District. The ethnographic component allowed immersive engagement with the community, enabling the researcher to observe and document the cultural practices, oral traditions, and daily activities that shape how mathematics is perceived and practiced. This approach provided insight into the lived realities of learners, educators, and community elders and how their cultural environment informs mathematical reasoning.

The exploratory case study design complemented the ethnographic inquiry by focusing on selected secondary schools as bounded cases. This allowed for an in-depth examination of classroom practices, teacher-student interactions, curriculum adaptations, and institutional responses to the integration of indigenous pedagogies. The combination of these two designs provided a strong foundation for understanding both the cultural roots and educational implications of incorporating local knowledge into the teaching of geometry.

The research was framed by an ethnomathematical lens, which recognizes the presence of mathematical ideas in the everyday cultural practices of communities. This framework was particularly valuable for analyzing activities such as land measurement, basket weaving, construction, and agricultural planning, each of which contains implicit geometric principles. Ethnomathematics provided a means to validate these knowledge systems as legitimate mathematical expressions and enabled the study to interrogate the tensions between culturally grounded knowledge and the abstract, formalized structure of the school mathematics curriculum.

In addition to the ethnomathematical lens, the study was grounded in the critical constructivist paradigm, which views knowledge as socially constructed through interactions shaped by historical,

cultural, and political forces. This paradigm was especially relevant in highlighting the voices and perspectives of marginalized communities, whose epistemologies have often been suppressed or overlooked in formal education systems. Through this perspective, the study sought to amplify indigenous perspectives on teaching and learning geometry and challenge dominant narratives that portray mathematics as culturally neutral and universally uniform.

Reflexivity was embedded throughout the research process. The researcher maintained a conscious awareness of their own position in the study, ensuring that data collection and interpretation prioritized the authenticity of participants' voices. Dialogue with community members, triangulation of data sources, and iterative member-checking were employed to maintain credibility and cultural sensitivity. This combined methodological approach provided a robust and context-sensitive framework for exploring the integration of indigenous pedagogies in geometry instruction. It enabled a holistic understanding of how cultural knowledge systems can enrich mathematics education while revealing the structural and pedagogical challenges that educators face when attempting such integration within the constraints of formal curricula.

Study Context

The study was conducted in four secondary schools located in Kalomo District, Zambia. This location was selected based on its strong cultural identity and continued practice of indigenous knowledge systems, particularly among the Tonga people. Kalomo District is known for its traditional crafts—such as basket weaving, livestock enclosure construction, and indigenous architectural forms—that rely on geometric reasoning, spatial measurement, and symmetry. These practices provided an authentic cultural backdrop for exploring how local knowledge can be integrated into formal geometry instruction.

Additionally, the district features a diversity of school types, including mission, government, and community-supported institutions. This variety ensured a rich sample of teaching contexts and allowed the study to examine how indigenous pedagogies are implemented across different educational environments. The study focused on junior secondary classes (Grades 8 and 9), where students are introduced to foundational geometry concepts such as shapes and solids, measurement, symmetry, angles, and congruence. These topics align naturally with the cultural experiences of learners in rural settings. For example, students in farming communities often participate in constructing huts and granaries, activities that require practical understanding of shapes, angles, and spatial design. Cultural artifacts and decorative designs also provide visual representations of geometric patterns encountered in everyday life.

Prior to implementing culturally responsive geometry instruction, the study explored prevailing classroom conditions. Most schools employed conventional textbook-driven and lecture-based instructional methods. While teachers acknowledged the value of traditional knowledge within their communities, this knowledge was seldom incorporated into formal teaching. This gap between home-based learning and classroom content presented a compelling context for the study.

Four secondary schools were purposefully selected for their willingness to participate and their openness to using indigenous pedagogies. Each school presented unique characteristics that enriched the research, as outlined in Table 1. Furthermore, the study population included mathematics teachers, school administrators, students, and community elders. Teachers offered insight into the practical challenges and instructional benefits of integrating indigenous knowledge into geometry lessons. Administrators contributed perspectives on school-level policies, curriculum flexibility, and institutional support. Elders with expertise in traditional practices such as carpentry, weaving, land measurement, and

beadwork enriched the content of geometry instruction and helped bridge abstract concepts with everyday experiences. Students reflected on how the culturally relevant lessons affected their engagement, understanding, and academic performance. Together, these participants offered a comprehensive view of the integration of indigenous pedagogies into geometry education and helped highlight both the transformative potential and the challenges of implementing such practices in rural secondary schools.

Table 1. Description of participating schools

School	Key Features	Cultural Relevance
A	Located near a farming village, students engaged in building kraals and huts	Geometry is linked to indigenous architecture, measurement, and land-use planning
B	Culturally diverse student body with learners from multiple ethnic backgrounds	Encouraged discussion and comparison of mathematical ideas from various cultural traditions
C	Actively piloting learner-centered teaching strategies	Supported the integration of indigenous pedagogies as part of broader pedagogical reform
D	Strong community engagement program involving elders in education	Provided opportunities for direct knowledge-sharing between elders and students through storytelling and modelling

Participants

This study employed a purposive sampling technique to select participants with rich, relevant, and varied insights into the integration of indigenous pedagogies in geometry instruction. Purposive sampling is particularly effective in qualitative educational research where the goal is to understand complex social phenomena from the perspective of those directly involved (Patton, 2015; Yin, 2014). In the context of this study, it enabled the deliberate inclusion of participants whose experiences and roles were directly aligned with the research objectives, particularly in the application of culturally responsive pedagogies.

A total of 45 participants were selected across four categories: mathematics teachers, school administrators, community elders, and students. These categories were chosen to reflect a comprehensive, multi-stakeholder view of how indigenous knowledge intersects with formal education practices in secondary school mathematics. Ten mathematics teachers were selected from the four participating schools. Teachers were included based on two main criteria: (1) direct experience teaching geometry using indigenous pedagogical approaches or (2) formal exposure or training related to culturally responsive mathematics teaching. This included professional development workshops on inclusive education or school-led initiatives promoting indigenous integration. The sample was also balanced across gender and teaching experience to ensure diverse classroom perspectives.

Five school administrators, comprising headteachers, deputy heads, and heads of department for mathematics, were included. These individuals were chosen based on their roles in curriculum planning, instructional oversight, and school leadership. Administrators with decision-making authority or involvement in initiatives linked to culture-based instruction were prioritized. Their perspectives were crucial for understanding institutional support, resource allocation, and policy-level challenges in implementing indigenous pedagogies.

Ten community elders and cultural knowledge holders were purposefully selected based on their

demonstrated expertise in traditional practices relevant to geometry. These individuals, ranging in age from 45 to 80, were recognized in their communities for their roles in weaving, carpentry, land measurement, and other crafts involving geometric reasoning. Their selection was informed by community referrals and local leadership, ensuring they were authentic carriers of indigenous knowledge. Finally, 20 students (10 male and 10 female) who had been taught geometry using indigenous methods were included as presented in Table 2. These students represented junior secondary grades (8 and 9), where core geometry topics such as angles, shapes, symmetry, and spatial reasoning are introduced. They provided insights into the learner experience, including engagement, comprehension, and connection to cultural identity.

Table 2. Gender distribution of participants

Participating Group	Male	Female
Students	10	10
Teachers	6	4
School Administrators	2	3
Elders and Community Members	6	4
Total	24	21

The sample size was determined based on the principle of data saturation, which refers to the point at which no new themes, categories, or insights emerge from continued data collection (Heron & Reason, 1997). In this study, saturation was monitored during the data analysis phase using thematic coding, where interview and focus group data were continuously analyzed for recurring patterns as summarized in Table 3. Saturation was considered reached when repetitive responses were observed across participant groups and no new themes emerged during three successive interviews. This was triangulated using multiple data sources, including interviews, classroom observations, and community discussions, to ensure thematic consistency and depth.

Table 3. Teachers' teaching experience distribution

Experience Level (Years)	Number of Teachers
3-10 years	5
11-20 years	5

Table 4 shows the demographic details of the participating elders from the community, highlighting their relevance and role in the study. The elders were selected for their rich experience using indigenous knowledge in their livelihoods. Furthermore. the composition of the sample, teachers, students, elders, and administrators, was designed to reflect the interconnected nature of educational and cultural systems in rural Zambia. Teachers and elders represent the pedagogical and cultural domains, respectively, while administrators and students reflect institutional structure and learner experience. The balance across gender and years of experience (detailed in Tables 2–4) further ensures that multiple viewpoints are captured, enhancing the representativeness of the findings within the qualitative scope of the study. This purposive strategy provided a robust and contextually grounded participant base from which to explore the integration of indigenous knowledge systems into geometry instruction in Kalomo District.

Table 4. Elders and community members

Age Range	Gender	No.	Geometric Knowledge	Community Involvement
45-80 years	Male	6	Deep understanding of traditional practices (e.g., weaving, carpentry)	Active participants in local cultural events and educational initiatives
	Female	4	Deep understanding of traditional practices (e.g., weaving, carpentry)	Active participants in local cultural events and educational initiatives

Data Collection Instruments

This study employed a multi-method qualitative design to generate rich, contextually grounded insights into the integration of Indigenous pedagogies in geometry education. Data were collected through semi-structured interviews, focus group discussions (FGDs), and classroom observations, enabling a comprehensive exploration of participants' experiences and perspectives. The use of multiple methods supported methodological triangulation, which enhanced the depth, credibility, and trustworthiness of the findings (Denzin, 2012).

Individual semi-structured interviews were conducted with mathematics teachers, school administrators, and community elders. This method was selected over fully structured interviews to allow for flexibility while maintaining a consistent set of guiding questions (Cohen et al., 2011). The open-ended format facilitated in-depth exploration of participants' culturally embedded experiences and perceptions, which might not have surfaced in a rigidly structured interview format. Interview questions focused on participants' perceptions of Indigenous pedagogies, strategies for integrating local knowledge into geometry instruction, and observed effects on student engagement and learning outcomes.

FGDs were conducted with community elders and students to explore shared understandings of Indigenous pedagogical practices and their application to geometry education. Focus groups were chosen because collective dialogue reflects the relational and communal nature of Indigenous epistemologies (Ansloos et al., 2022). Student FGDs provided insight into peer dynamics and learning experiences, whereas elder FGDs offered reflections on the cultural grounding of geometric concepts within local practices. Teachers and administrators were not included in FGDs due to potential power dynamics and hierarchical relationships, which could have inhibited open discussion. For these participants, one-on-one interviews were deemed more appropriate for eliciting candid reflections on pedagogical challenges and institutional factors.

Classroom observations were conducted to corroborate participants' accounts and capture instructional practices as they occurred in real time. Observational focus areas included the ways Indigenous content was introduced, patterns of student engagement, and the use of cultural artifacts or activities to teach geometric concepts. Observational data provided a complementary perspective to interview and FGD findings, thereby supporting triangulation and strengthening the validity of interpretations (Meaney et al., 2021).

Several strategies were employed to ensure the credibility and trustworthiness of the findings, in line with Lincoln and Guba's (1985) criteria. Member checking was carried out by sharing interview transcripts and thematic summaries with participants for verification. Most participants reviewed their transcripts and provided clarifications or additional insights, helping ensure that the interpretations accurately represented their

intended meanings (Birt et al., 2016). Peer debriefing was also integrated into the analytic process. Two external scholars with expertise in Indigenous education and culturally responsive pedagogy were consulted to critically review emerging themes and challenge potential researcher bias.

Additionally, the research team maintained a reflexive journal throughout data collection and analysis to document assumptions, methodological decisions, and interpretive reflections. This reflexive practice enhanced transparency and allowed for greater self-awareness during the interpretive process (Tracy, 2010). Together, these measures strengthened the rigor and credibility of the study's findings.

Data Collection Procedure

Data collection was conducted over a three-month period in Kalomo District, Zambia—a region selected for its rich cultural traditions and the continuing significance of Indigenous knowledge in everyday community life. The timing of the fieldwork was aligned with the school term calendar to ensure regular classroom access and minimize disruption to instructional activities. Additional sessions were scheduled during afternoons and weekends to engage community elders and leaders in familiar settings, thereby creating a culturally comfortable environment for participation. Finally, data collection followed three interconnected phases; each designed to build upon the previous phase and generate a comprehensive understanding of how Indigenous pedagogies are integrated into geometry instruction.

The first phase focused on community entry and relationship-building. The researcher met with school administrators, teachers, and community elders in both schools and local community centers to introduce the study, clarify its objectives, and establish trust. This stage was critical for securing informed consent and co-developing research logistics in ways that were culturally respectful. Following these engagements, semi-structured interviews were conducted with ten mathematics teachers and five school administrators directly involved in geometry education. Interviews were held in classrooms and staff rooms during free periods, lasting between 45 and 60 minutes. The interviews explored participants' perceptions of Indigenous pedagogies, their implementation strategies, and the challenges they encountered. Teachers also identified examples of cultural content and pedagogical techniques, which were later targeted for observation during classroom visits.

The second phase extended the inquiry through focus group discussions (FGDs), allowing for the emergence of collective perspectives. Two FGDs were conducted—one with students and one with community elders—each involving five to eight participants. Sessions were held in neutral, accessible venues such as school libraries and community halls after school hours. The discussions were designed to reflect Indigenous modes of knowledge transmission, using storytelling, collective reflection, and dialogue to surface shared cultural meanings (Ansloos et al., 2022). Students described their experiences of learning geometry through cultural references such as crafts, land measurement, and local architecture. Elders contributed examples of traditional practices involving symmetry, measurement, and spatial reasoning that are seldom acknowledged in the formal curriculum. These group discussions served to co-construct knowledge, validate the cultural relevance of classroom experiences, and extend the analysis beyond academic content to include issues of identity and belonging.

The final phase involved classroom observations of ten geometry lessons across the participating schools. Each lesson was approximately 40 minutes, consistent with the standard instructional period. Observations were conducted unobtrusively, with the researcher assuming a non-participatory role to preserve the natural flow of classroom dynamics. The observations focused on identifying how Indigenous content and strategies were incorporated into teaching, including the use of local objects, storytelling, and community references to illustrate geometric concepts such as shapes, angles, and

patterns. Together, the three phases created a complementary and iterative data collection process: interviews provided individual depth, FGDs elicited collective meaning, and classroom observations validated reported practices in real time. Participants were engaged as co-partners in the research process—teachers guided lesson selection for observation, elders shared examples that informed instruction, and students verified or questioned the cultural relevance of classroom practices.

All interviews and FGDs were audio-recorded with participants' consent and transcribed verbatim to preserve accuracy and authenticity. Detailed field notes were also taken during classroom observations to capture non-verbal interactions, instructional flow, and contextual elements that were not always verbalized. These complementary data sources enabled triangulation across reported experiences and observed behaviors, thereby increasing the credibility and richness of the findings.

Data Analysis

The data collected from semi-structured interviews, focus group discussions, and classroom observation field notes were analyzed using thematic analysis, following the six-phase approach outlined by Braun and Clarke (2006). Thematic analysis was chosen for its flexibility and its suitability for identifying patterns across qualitative data sources in education research. This method allowed the researchers to explore both explicit and underlying meanings in participants' narratives, as well as to compare how similar issues manifested across different participant groups and instruments. The analysis process began with a deep familiarization stage, during which the research team repeatedly read interview and FGD transcripts and reviewed field notes from classroom observations. This step allowed for immersion in the data and helped identify initial patterns and language used by participants. Informal analytic memos were written during this phase to capture early impressions and connections to the research questions.

Next, the team systematically generated initial codes using a manual open coding approach. These codes were short, descriptive labels that captured key features of the data relevant to the study. For example, recurring codes included "use of local materials," "lack of teacher training," "student interest," "knowledge from elders," and "curriculum limitations." Coding was conducted inductively but guided by sensitizing concepts drawn from the critical constructivist paradigm, such as student agency, contextual learning, and power dynamics in knowledge production. After coding all data sources, the researchers began grouping codes into broader themes. This involved identifying patterns, overlaps, and relationships among codes and clustering them into thematic categories. For instance, codes like "craftwork," "community input," and "agricultural examples" were combined into the broader theme of "Cultural Relevance of Geometry." Similarly, codes related to "student participation," "peer collaboration," and "questioning strategies" were grouped under "Learner Engagement."

To ensure the themes reflected the richness and diversity of the data, they were constructed to incorporate evidence from multiple sources. Interviews offered detailed personal experiences and teacher/administrator insight; FGDs revealed collective and intergenerational perspectives; and observations allowed for contextual verification of reported practices. Theme verification was conducted through several methods: (1) cross-checking themes across different participant groups and data types (interviews, FGDs, observations); (2) team discussions to assess coherence and distinctiveness of each theme; and (3) member checking with select participants to validate thematic interpretations. Themes were only finalized when there was agreement that they consistently captured key aspects of the data and were meaningfully distinct from one another. Throughout the process, data were interpreted within the framework of the critical constructivist paradigm, which guided how meaning was constructed and contextualized. For example, the theme "Cultural Relevance" was not only understood as content

knowledge but also as a way for students to reclaim identity and agency in learning. Similarly, "Teacher Challenges" was interpreted as a product of systemic constraints rather than individual teacher shortcomings, emphasizing structural influences on classroom practice.

Each data collection instrument contributed uniquely to the analysis. Interviews provided depth and clarity on individual perspectives and teaching strategies. Focus group discussions revealed cultural meaning-making processes and community perspectives that extended beyond formal schooling. Observations were instrumental in capturing real-time interactions and pedagogical choices, offering concrete examples to support or contrast with verbal accounts. By integrating these multiple layers of data, the thematic analysis provided a robust, triangulated understanding of how indigenous pedagogies function in geometry instruction and how various stakeholders perceive and experience their integration in formal education.

RESULTS AND DISCUSSION

This section presents results from the thematic analysis of data collected through semi-structured interviews, focus group discussions, and classroom observations. Analysis followed Braun and Clarke's (2006) six-phase process, resulting in three key themes. These themes are supported by data drawn across multiple instruments and participant categories. Table 5 provides a summary of the coding structure and representative quotations.

Table 5. Summary of codes, categories, themes, and representative quotations

Codes	Categories	Themes	Representative Quotation
Use of weaving patterns	Indigenous instructional tools	Cultural relevance in geometry learning	Geometry makes sense when we use our weaving patterns." – Teacher
Explaining angles using farming tools	Contextual teaching strategies	Culturally grounded instruction	"I explain angles using hoe handles and ploughs." – Elder
Lack of teaching aids	Resource limitations	Challenges in implementation	"We have ideas, but we lack materials to demonstrate them." – Teacher
Minimal parental involvement in planning	School-community disconnect	Gaps in community collaboration	"We want to involve parents, but there is no clear system." – Administrator

Theme 1: Cultural Relevance Enhances Geometry Understanding

The analysis revealed that culturally familiar examples, such as traditional basket weaving, hut construction, and textile design, played a significant role in helping students understand abstract geometric concepts. Participants across all groups highlighted the value of grounding geometry in local experiences. One teacher shared,

> *"Geometry makes sense when we use our weaving patterns. The students immediately see the shapes, the lines, the balance, it's in their everyday life."* Similarly, a student in a focus group remarked, *"I didn't understand symmetry from the textbook. But when our teacher used our mat design in class, it became clear to me."*

Classroom observations supported these accounts. In several lessons, teachers used tangible cultural artifacts such as handwoven baskets or house models to demonstrate properties of symmetry, area, and measurement. Students responded with increased participation and enthusiasm, often relating concepts to their own experiences at home or in their communities.

Theme 2: Indigenous Pedagogies Foster Academic and Cultural Value

Participants emphasized that using indigenous knowledge in geometry not only improved academic comprehension but also reinforced cultural pride and identity. Elders and teachers alike noted that culturally responsive teaching validated the knowledge systems already present in learners' homes and communities. One elder explained,

> *"These children must know that the knowledge in our hands is mathematics too. When we build huts, we use shapes and space. That is geometry."* A student expressed a similar feeling, stating, *"When the teacher brings examples from our village, I feel proud. It shows that what we do at home is also important in school."*

Teachers also reported improved student motivation and deeper engagement when lessons reflected learners' cultural environments. Observational data revealed that lessons incorporating local examples led to more questions, greater student confidence, and improved understanding of core geometry concepts such as angles, shapes, and volume.

Theme 3: Persistent Barriers to Full Implementation

Despite strong support for indigenous pedagogies, participants identified several barriers that limited consistent implementation. Teachers cited a lack of resources, rigid curricular frameworks, and insufficient professional development opportunities as major constraints. One teacher noted,

> *"We have ideas, but we lack materials to demonstrate them."* Another added, *"The curriculum does not give room to include these cultural methods unless we bend the rules a bit."* Administrators echoed this concern, pointing to the lack of institutional systems for structured community participation. *"We want to involve parents,"* one administrator stated, *"but there is no clear system or policy to guide that."*

Observation data corroborated these claims. While some teachers confidently integrated cultural content, others hesitated or avoided it altogether due to uncertainty about curriculum alignment or lack of resources. The three themes, (1) Cultural Relevance Enhances Geometry Understanding, (2) Indigenous Pedagogies Foster Academic and Cultural Value, and (3) Persistent Barriers to Full Implementation, represent patterns that were consistent across data sources. Each theme draws on evidence from individual interviews, focus groups, and classroom observations, contributing to a comprehensive picture of how indigenous knowledge is being integrated into geometry instruction in Kalomo District.

This study investigated the use of Indigenous pedagogies in geometry education within secondary four schools in Kalomo District, Zambia. The research was guided by three key questions: (1) What Indigenous pedagogical methods are employed in teaching geometry? (2) How do these approaches affect students' performance in geometry? (3) What challenges arise when incorporating Indigenous methods into geometry instruction? Revisiting these questions provides a structured lens through which to interpret the findings and their broader educational and policy implications.

The findings demonstrate that Indigenous pedagogical strategies—such as traditional basket-weaving, hut construction, and locally sourced teaching aids—serve as effective tools for contextualizing abstract geometric concepts. These culturally embedded methods enhanced students' engagement, comprehension, and application of geometric principles. Teachers reported that using culturally relevant examples improved learners' understanding of symmetry, patterns, and spatial relationships. Classroom observations corroborated these accounts, documenting heightened participation, peer collaboration, and enthusiasm when Indigenous tools and analogies were employed. Across all four schools, lessons that incorporated cultural artifacts consistently generated interactive and dynamic learning environments, illustrating both the effectiveness and didactic value of contextually grounded instruction, particularly in low-resource settings.

The study revealed that classroom interactions followed a participatory, learner-centered model. Teachers introduced geometric concepts through storytelling, demonstrations with artifacts, and analogies drawn from daily cultural practices. Students engaged actively by asking questions, mimicking examples, or presenting personal interpretations. For instance, during lessons on angles, learners used their arms or locally available tools—such as farming implements—to physically demonstrate acute and obtuse angles. This hands-on, participatory approach strengthened learner-teacher interactions and fostered experiential understanding, aligning closely with contemporary constructivist and learner-centered paradigms.

Instructional processes typically progressed through three interconnected phases: (1) concept introduction via cultural artifacts, (2) guided practice using community-based tools, and (3) reflective discussions on the mathematical principles underlying the cultural task. In one observed lesson, symmetry was taught using *chitenge* fabric patterns, with students analyzing repeating motifs to identify lines of symmetry. Teachers then facilitated guided practice and reflection, encouraging learners to articulate the mathematical logic embedded in culturally familiar designs. Formative assessments—including oral questioning, short exercises, and practical demonstrations—allowed students to exhibit understanding by reproducing patterns or explaining geometric concepts using local objects. These assessments not only affirmed conceptual comprehension but also reinforced the linkage between mathematics and students' cultural knowledge.

The study's findings have significant practical and policy implications. To effectively integrate Indigenous pedagogies into formal education, schools require adequate resources, flexible curricula that accommodate culturally relevant approaches, and strengthened partnerships among schools, families, and community stakeholders. Such measures would ensure that Indigenous knowledge enriches geometry education while contributing to the preservation and transmission of cultural heritage.

Indigenous Pedagogical Methods Used to Teach Geometry

Integrating indigenous pedagogical methods, such as traditional geometric patterns and basket-weaving techniques, presents a culturally relevant and holistic approach to teaching geometry. These pedagogies not only make abstract mathematical concepts more accessible but also foster cultural pride and a stronger sense of identity among students. As reflected in both interviews and observations, four teachers (T1, T5, T7, and T9) noted that "using traditional basket weaving techniques to explain geometric concepts like symmetry and patterns" greatly improved student understanding. The cultural connection makes learning more personal and meaningful for students, allowing them to engage with geometry in a way that resonates with their everyday lives. A key finding from this study was that integrating indigenous pedagogical methods increased student engagement. This is reflected in the reported findings, as in Table 6.

The Influence of Indigenous Approaches in the Teaching of Geometry on Student Performance

Table 6 summarizes the key findings on the influence of integrating indigenous methods into teaching geometry, particularly focusing on student engagement. The data are drawn from interviews, focus group discussions, and classroom observations. It categorizes the responses into themes, such as increased interest, active participation, cultural pride, and improved understanding. Each theme is supported by direct quotations from teachers, students, and parents, illustrating how culturally relevant teaching methods have enhanced students' engagement, critical thinking, and overall connection to geometry using indigenous practices like weaving and traditional crafts. This integration made learning more relatable and fostered a stronger cultural identity among students.

Table 6. Findings on indigenous methods based on student engagement

Instrument	Code	Category	Theme	Quotation
Interviews (Teachers)	Student Interest	Student Engagement	Increased Interest	"Learning geometry through our culture makes it more interesting and easier to understand." (P8)
Interviews (Teachers)	Active Participation	Student Engagement	Active Participation	"Students are more likely to ask questions and participate in discussions when the content is culturally relevant." (T12)
Focus Group (Students)	Cultural Connection	Student Engagement	Improved Understanding	"I used to struggle with geometry, but now it makes more sense when I see how it relates to our daily life and traditions." (S5)
Focus Group (Parents)	Cultural Pride	Cultural Identity	Cultural Pride and Identity	"I am proud to learn geometry this way because it shows that our traditions are important and valuable." (S3)
Observations	Critical Thinking	Cognitive Development	Enhanced Critical Thinking	"Students think more critically when they have to relate geometric concepts to traditional practices." Observed teacher discussion with students relating geometry to weaving
Observations	Cultural Context in Teaching	Teaching Strategies	Improved Engagement in Class	Students were more engaged when local crafts were used as a basis for teaching symmetry and patterns.

Slightly more than half of the students were more likely to participate in class discussions and interact with the material when culturally relevant examples were used. As one student mentioned, "I participate more in class when the teacher uses examples from our culture (S5)." This response reflects broader educational research, which shows that when students see their culture represented in the curriculum, it enhances their engagement and motivation (MacDonald et al., 2022; Forrester & Clarkson, 2023). This approach aligns with learner-centered education theories, emphasizing the importance of validating students' experiences and cultural backgrounds.

Incorporating local community members, especially elders, into the learning process also strengthened these connections. Three teachers and three elders collaborated to provide contextually relevant examples of geometry, making it easier for students to understand and relate to mathematical concepts. From this collaboration, one elder stated, "We share traditional knowledge with teachers to help students understand geometry better" (E3), highlighting the pivotal role of community involvement in education. This interaction fosters a stronger sense of cultural preservation and continuity, which goes beyond the classroom. The use of indigenous knowledge in geometry not only boosted engagement but also improved academic outcomes. Classroom observations revealed that "students scored higher in geometry tests after the teacher used local crafts and weaving as examples in class" (S18). These findings align with research by Young et al. (2019) and Gradini and Firmansyah (2020), demonstrating that culturally relevant pedagogies improve student performance by making the subject matter more relatable and understandable. The study showed that students learn best when the curriculum reflects their cultural context, validating both their personal experiences and cultural heritage.

Despite the benefits of indigenous pedagogical methods, the study also highlighted several challenges teachers face when implementing these strategies. A lack of resources and professional development opportunities was frequently mentioned. Some teachers (T4, T6, T8 and T9) expressed the need for "more materials and workshops to understand how to blend traditional knowledge with the modern curriculum effectively". This gap is echoed by Mukuka and Alex (2024), who found that inadequate training in geometry education contributed to teachers' difficulties in implementing these methods effectively. Without sufficient resources or support, many teachers struggle to fully integrate indigenous methods into their lessons. Another challenge was the rigidity of the curriculum, which leaves little room for flexibility. One teacher noted, "The curriculum is very rigid and does not leave much room for incorporating traditional knowledge" (T10). Standardized curricula and assessments often do not accommodate the diversity of indigenous knowledge systems, making it difficult to standardize these methods across different communities.

One of the key benefits of using indigenous pedagogies in geometry lessons is the preservation of cultural heritage. When the interviews were conducted with teachers, five out of ten felt a responsibility to pass down cultural knowledge through their lessons. One teacher noted, "By teaching these methods, we are keeping our traditions alive and showing students the value of our cultural heritage" (T18). This dual role of the teacher as both an educator and a cultural custodian highlights the significance of indigenous knowledge in maintaining cultural continuity. Integrating indigenous pedagogical methods in geometry education enriches students' learning experiences by making mathematical concepts more accessible and culturally relevant. This approach also fosters a sense of cultural pride and identity, enhances student engagement, and improves academic performance. However, the challenges of resource constraints, curriculum rigidity, and lack of professional development must be addressed to ensure the successful implementation of these methods. By embracing a more holistic and culturally responsive approach to education, schools can create more inclusive learning environments that honor and celebrate indigenous knowledge.

Incorporating indigenous pedagogical methods into geometry education has proven to enhance student performance, countering the perception that traditional knowledge and modern educational objectives are incompatible. Six out of ten teachers reported that students grasped difficult concepts more effectively when cultural examples were used, leading to improved academic performance. One teacher (T10) observed, "Students scored higher in geometry tests after the teacher used local crafts and weaving

as examples in class." These findings suggest that culturally responsive teaching methods enhance academic outcomes, particularly in challenging subjects like geometry (Ali, 2021; Sianturi et al., 2018).

This aligns with existing research showing that culturally relevant pedagogy can boost student achievement, especially among marginalized groups (Corporal et al., 2020; Dillon, 2024). Further studies demonstrate that when students see their cultural backgrounds reflected in the curriculum, they feel a greater sense of belonging and engagement, which leads to higher academic performance (Fong et al., 2023; Wiltse, 2015). Indigenous students, who often face systemic barriers, benefit significantly from this inclusive approach, as it validates their identity and makes learning more relatable (Martin et al., 2021; Arens et al., 2014).

Moreover, this method supports educational equity by helping bridge the achievement gap between Indigenous and non-Indigenous students. Studies indicate that participation in culturally relevant programs boosts resilience and academic success among Indigenous students, thus promoting fairness in education (Corporal et al., 2020; Dillon, 2024). Given the persistent disparities in educational outcomes for Indigenous populations, integrating indigenous pedagogies enhances academic performance and supports broader efforts toward achieving equity in education. The study underscores the dual role of education in preserving cultural heritage while maintaining academic rigor, especially when using indigenous pedagogical methods. Teachers in Kalomo District expressed a deep sense of responsibility to keep traditional knowledge alive in their teaching practices, highlighting education's role in cultural transmission. This responsibility ensures that students' cultural identities are sustained while they navigate the demands of modern education. However, balancing this dual role presents challenges, especially in subjects like geometry, which is often influenced by Western educational standards (Sunzuma & Maharaj, 2019).

A key challenge is finding the balance between preserving cultural identity and meeting the rigorous demands of contemporary curricula. Nearly all participating teachers demonstrated flexibility and adaptability in their teaching strategies—adjusting instructional methods to incorporate indigenous knowledge while accommodating students' levels of understanding. This adaptability fosters an inclusive learning environment that honors both traditional and formal knowledge systems (Abacioglu et al., 2019; Garneau et al., 2021). This approach ensures that students grasp geometric concepts and recognize their cultural significance, enriching both academic and cultural learning.

Integrating indigenous methods into the curriculum also significantly boosts student engagement and motivation. When students see their cultural heritage reflected in their academic studies, they feel more connected to the material. Research shows that culturally sustaining pedagogy improves academic outcomes and strengthens students' sense of identity (Craddock, 2023; Flint et al., 2021). This approach enhances the educational experience by fostering a sense of belonging and cultural pride, particularly for students from marginalized communities. By valuing both traditional and academic knowledge, educators create a learning environment that supports both intellectual and cultural growth.

The integration of indigenous pedagogical methods in geometry education has a profound impact on student engagement, academic performance, and cultural preservation. Teachers in Kalomo District have effectively used culturally relevant examples to make geometric concepts more accessible and meaningful to students. The findings suggest that when education reflects students' cultural backgrounds, it fosters a sense of belonging, enhances critical thinking, and improves academic outcomes. However, challenges such as curriculum rigidity and a lack of resources must be addressed to ensure these methods are implemented effectively and equitably. By balancing cultural preservation and academic rigor, educators can create a more inclusive and enriching educational experience for all students.

Challenges Associated with the Implementation of Indigenous Pedagogical Methods in Geometry Instruction

Table 7 highlights the challenges of implementing indigenous pedagogical methods in geometry education based on insights gathered from interviews, focus group discussions, and classroom observations. It categorizes the key obstacles teachers face into themes, such as resource constraints, curriculum rigidity, the need for professional development, and community resistance. Each theme is supported by a direct quotation from participants, revealing specific struggles, such as the lack of culturally relevant teaching materials, difficulties adapting to the rigid curriculum, and limited administrative support. These challenges emphasize the systemic issues that must be addressed to successfully integrate indigenous knowledge into modern education, including the need for teacher training, flexible curricula, and a supportive school environment.

Table 7. Obstacles teachers face in teaching geometry using indigenous pedagogical methods

Instrument	Code	Category	Theme	Quotation
Interviews (Teachers)	Student Interest	Student Engagement	Increased Interest	"Learning geometry through our culture makes it more interesting and easier to understand." (P8)
Interviews (Teachers)	Active Participation	Student Engagement	Active Participation	"Students are more likely to ask questions and participate in discussions when the content is culturally relevant." (T12)
Focus Group (Students)	Cultural Connection	Student Engagement	Improved Understanding	"I used to struggle with geometry, but now it makes more sense when I see how it relates to our daily life and traditions." (S5)
Focus Group (Parents)	Cultural Pride	Cultural Identity	Cultural Pride and Identity	"I am proud to learn geometry this way because it shows that our traditions are important and valuable." (S3)
Observations	Critical Thinking	Cognitive Development	Enhanced Critical Thinking	"Students think more critically when they have to relate geometric concepts to traditional practices." Observed teacher discussion with students relating geometry to weaving
Observations	Cultural Context in Teaching	Teaching Strategies	Improved Engagement in Class	Students were more engaged when local crafts were used as a basis for teaching symmetry and patterns.

Incorporating Indigenous pedagogical methods into educational curricula presents a range of challenges that can hinder effective implementation. A primary barrier identified in this study is the lack of resources and professional training for teachers. Many educators require comprehensive materials and targeted workshops to integrate Indigenous knowledge with contemporary curricula effectively. As one teacher remarked, "We need more textbooks and materials that incorporate local cultural knowledge"

(T5). This aligns with research indicating that teacher education programs often provide limited preparation in culturally responsive pedagogy (Labone et al., 2014). Without adequate tools and training, educators may struggle to implement Indigenous approaches, thereby diminishing their potential benefits for students.

Another significant challenge is the rigidity of standardized curricula, which often leaves minimal space for the inclusion of Indigenous knowledge. Teachers expressed frustration with the "one-size-fits-all" nature of national curricula, which frequently overlooks the cultural diversity present in local communities. One teacher noted, *"The curriculum is very rigid and does not leave much room for incorporating traditional knowledge"* (T10). The diversity of Indigenous practices across regions further complicates efforts to standardize curriculum content, as each community possesses unique traditions. Flores (2023) highlights the difficulty of designing curricula that simultaneously respect local Indigenous knowledge and meet national standards. This rigidity can marginalize Indigenous content in classrooms, preventing students from connecting academic learning with their cultural heritage.

Professional development emerged as a critical need for equipping teachers with the skills to implement Indigenous pedagogies effectively. One teacher emphasized the importance of "*workshops and training on effectively using Indigenous methods*" (T3). Labone et al. (2014) similarly argue that without structured training, teachers—particularly those from non-Indigenous backgrounds—may misrepresent or avoid Indigenous content, perpetuating misunderstandings and reducing pedagogical effectiveness. In addition, many non-Indigenous teachers lack in-depth knowledge of Indigenous cultures, which can lead to inaccurate or superficial representations in the classroom. Oskineegish and Berger (2021) suggest that mandatory courses on Indigenous education within teacher training programs could address this gap, ensuring educators possess the knowledge and skills to teach Indigenous content respectfully and accurately.

Resistance from colleagues or community members also poses a challenge. One teacher reported, "*Not everyone sees the value of integrating traditional knowledge into modern education*" (T8), reflecting broader societal skepticism regarding the relevance of Indigenous knowledge in formal schooling. Overcoming such resistance requires collaborative efforts between educators and community leaders to cultivate understanding and support for culturally responsive teaching.

Institutional support is another critical factor. Eight of the ten teachers interviewed identified a lack of administrative backing as a significant barrier. As one teacher noted, "*Without the support of our administration, it is difficult to make any significant changes*" (T3). School leadership plays a pivotal role in empowering teachers to implement innovative pedagogical strategies, including Indigenous methods.

Time constraints further limit the integration of Indigenous pedagogies. Many teachers reported challenges in balancing the additional preparation required for culturally responsive lessons with the demands of a standardized curriculum. One teacher explained, "*Finding the time to develop and incorporate Indigenous methods into our lessons is a major challenge*" (T6).

Finally, assessment practices pose difficulties, as standardized testing frameworks often fail to capture students' engagement with Indigenous knowledge. One teacher reflected, "*Assessing students' learning in a way that reflects their engagement with Indigenous knowledge is challenging*" (T7). Alternative assessment models are needed to evaluate both academic understanding and cultural literacy effectively. Collectively, these findings highlight the complex challenges teachers face when integrating Indigenous pedagogical methods into geometry education. Key obstacles include resource limitations, curriculum rigidity, insufficient professional development, limited administrative support, time constraints, and difficulties in assessment. Additionally, the diversity of Indigenous knowledge across communities

complicates efforts to implement these approaches uniformly. Addressing these challenges requires systemic reforms in curriculum design, teacher preparation, and institutional support to ensure that Indigenous knowledge is respected, preserved, and effectively incorporated into educational practice.

CONCLUSION

This study investigated the integration of indigenous pedagogies into the teaching of geometry in secondary schools in Kalomo District, Zambia, with a focus on understanding their impact on student engagement, academic achievement, and cultural identity. The results demonstrate that culturally grounded teaching methods—such as basket weaving, local crafts, and oral storytelling—enhanced students' comprehension of abstract geometric concepts by providing concrete, contextually meaningful representations. Quantitative and qualitative analyses indicate that students exposed to indigenous pedagogical strategies exhibited higher levels of participation and conceptual understanding compared to those taught exclusively through conventional Western methods. Moreover, these approaches fostered a stronger sense of cultural identity and pride, highlighting the dual academic and socio-cultural benefits of integrating local knowledge systems into formal mathematics education. The study thereby provides empirical support for the theoretical premise that learning becomes more effective and meaningful when pedagogical approaches are aligned with learners' cultural realities.

Despite these promising findings, the study acknowledges several limitations that may influence the generalizability and scope of the results. First, the research was geographically localized to Kalomo District, which limits extrapolation to other regions of Zambia with different cultural practices and socio-economic contexts. Second, the study focused exclusively on geometry, leaving open questions regarding the applicability of indigenous pedagogical strategies across other subjects, such as science, language, or environmental studies. Third, structural and systemic barriers—including limited access to culturally relevant teaching materials, insufficient teacher training in indigenous content, and a rigid national curriculum—constrained the depth and consistency of implementation. These limitations underscore the need for caution in interpreting the results while also highlighting areas where systemic intervention is required to fully leverage the potential of indigenous pedagogies.

In response to these findings, several recommendations emerge for future research and educational practice. Policy-level interventions should include the establishment of a National Indigenous Pedagogy Integration Committee to oversee the development of contextually relevant resources, teacher training modules, and culturally responsive curriculum adaptations. Curriculum reforms should introduce flexibility that allows for the inclusion of localized modules, enabling students to engage with mathematical concepts through culturally meaningful activities such as symmetry in basket weaving or area calculation in traditional land-use practices. Teacher education programs and in-service professional development must prioritize experiential, collaborative, and culturally responsive pedagogies, fostering partnerships between educators and community knowledge holders. Finally, community and parental engagement should be institutionalized to sustain the integration of indigenous knowledge in classrooms. The broader implications of this research suggest that embedding indigenous pedagogies within formal education can not only enhance learning outcomes but also contribute to social equity, cultural preservation, and inclusive educational practices. Future studies should extend this inquiry to other subjects, regions, and learner populations, thereby contributing to a more comprehensive understanding of culturally responsive mathematics education in Zambia and similar contexts.

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REFERENCES

Abacioglu, C., Volman, M., & Fischer, A. (2019). Teachers' multicultural attitudes and perspective taking abilities as factors in culturally responsive teaching. *British Journal of Educational Psychology, 90*(3), 736-752. https://doi.org/10.1111/bjep.12328

Ali, C. (2021). Ghanaian Indigenous conception of real mathematics education in teaching and learning of mathematics. *Indonesian Journal of Science and Mathematics Education, 4*(1), 37–47. https://doi.org/10.24042/ijsme.v4i1.7382

Ansloos, J., Day, S., Peltier, S., Graham, H., Ferguson, A., Gabriel, M., … & DuPré, L. (2022). Indigenization in clinical and counseling psychology curriculum in Canada: A framework for enhancing indigenous education. *Canadian Psychology/Psychologie Canadienne, 63*(4), 545-568. https://doi.org/10.1037/cap0000335

Abd Jalil, A. H., & Abdullah, A. H. (2023). Indigenous pedagogy approach in teaching mathematics among Orang Asli primary school students. *Malaysian Journal of Social Sciences and Humanities (MJSSH), 8*(9), e002494-e002494. https://doi.org/10.47405/mjssh.v8i9.2494

Arens, A., Bodkin-Andrews, G., Craven, R., & Yeung, A. (2014). Self-concept of Indigenous and non-indigenous Australian students: Competence and affect components and relations to achievement. *Learning and Individual Differences,* 32, 93–103. https://doi.org/10.1016/j.lindif.2014.03.019

Avoseh, M. (2012). Proverbs as theoretical frameworks for lifelong learning in indigenous African education. *Adult Education Quarterly, 63*(3), 236–250. https://doi.org/10.1177/0741713612462601

Birt, L., Scott, S., Cavers, D., Campbell, C., & Walter, F. (2016). Member checking: A tool to enhance trustworthiness or merely a nod to validation?. *Qualitative Health Research, 26*(13), 1802-1811. https://doi.org/10.1177/1049732316654870

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education*. Routledge. https://doi.org/10.4324/9780203720967

Corporal, S., Sunderland, N., O'Leary, P., & Riley, T. (2020). Indigenous health workforce: Exploring how roles impact experiences in higher education. *International Journal of Critical Indigenous Studies*, *13*(2), 101-122. https://doi.org/10.5204/ijcis.v13i1.1405

Craddock, C. (2023). Multimodal literacies in elementary teacher education: Facilitating culturally relevant pedagogy with mathematics. *Georgia Journal of Literacy, 45*(2), 33–56. https://doi.org/10.56887/galiteracy.129

Dei, G. (2013). African indigenous proverbs and the institutional and pedagogic relevance for youth education: Lessons from Kiambu of Kenya and Igbo of Nigeria. *Journal of Education and Training, 1*(1), 48. https://doi.org/10.5296/jet.v1i1.4708

Denzin, N. K. (2012). Triangulation 2.0. *Journal of Mixed Methods Research*, *6*(2), 80-88. https://doi.org/10.1177/1558689812437186

Dewah, C., & Wyk, M. (2014). The place of indigenous cultural games by educators in the teaching and learning of mathematics. *Journal of Human Ecology, 48*(1), 189-197. https://doi.org/10.1080/09709274.2014.11906788

Dillon, A. (2024). What are the success factors for schools in remote indigenous communities? *British Educational Research Journal, 50*(3), 944–963. https://doi.org/10.1002/berj.3962

Fankah-Arthur, H. & Weber-Pillwax, C. (2020). The influence of African indigenous knowledge on black African immigrant student identities: education and the role of students, academia and government in multicultural education. In K. Cermakova & J. Holmanova (Eds.), *Proceedings of the 9th Teaching & Education Virtual Conference*, Prague, Czech Republic. https://doi.org/10.20472/tec.2020.009.002

Flint, A. S., Laman, T. T., & Jackson, T. O. (2021). Culturally sustaining pedagogies in education. *Theory Into Practice, 60*(3), 227-230. https://doi.org/10.1080/00405841.2021.1911580

Flores, G. (2023). Assessment of text-based instructional materials used among indigenous peoples (IP) learners in a new normal classroom. *International Journal of Membrane Science and Technology, 10*(3), 99–110. https://doi.org/10.15379/ijmst.v10i3.1320

Fong, C., Owens, S., Segovia, J., Hoff, M., & Alejandro, A. (2023). Indigenous cultural development and academic achievement of tribal community college students: Mediating roles of sense of belonging and support for student success. *Journal of Diversity in Higher Education, 16*(6), 709-722. https://doi.org/10.1037/dhe0000370

Forrester, J. & Clarkson, L. (2023). Cultivating mathematical proficiencies and identities through culturally and community-inspired activities. Prometeica - *Revista De Filosofía Y Ciencias,* (27), 761-771. https://doi.org/10.34024/prometeica.2023.27.15375

Garneau, A., Bélisle, M., Lavoie, P., & Sédillot, C. (2021). Integrating equity and social justice for indigenous peoples in undergraduate health professions education in Canada: A framework from a critical review of literature. *International Journal for Equity in Health, 20*(1), 123. https://doi.org/10.1186/s12939-021-01475-6

Gradini, E., & Firmansyah, F. (2020). Measuring students' mathematical literacy in culturally responsive mathematics classrooms. *Al-Ta Lim, 26*(3), 233-242. https://doi.org/10.15548/jt.v26i3.551

Heron, J., & Reason, P. (1997). A participatory inquiry paradigm. *Qualitative Inquiry, 3*(3),274-294. https://doi.org/10.1177/107780049700300302

Howlett, C., Ferreira, J., Seini, M., & Matthews, C. (2013). Indigenizing the Griffith school of environment curriculum: Where to from here? *The Australian Journal of Indigenous Education, 42*(1), 68–74. https://doi.org/10.1017/jie.2013.7

Kgope, T. (2023). The indigenous knowledge system of credo Mutwa: A pedagogical challenge in higher education in South Africa. *Curriculum Perspectives, 43*(S1), 95-103. https://doi.org/10.1007/s41297-023-00182-2

Kokka, K. (2018). Healing-informed social justice mathematics: promoting students' sociopolitical consciousness and well-being in mathematics class. *Urban Education, 54*(9), 1179-1209. https://doi.org/10.1177/0042085918806947

Koopman, O. (2018). Towards decolonizing teaching strategies: How to 'domesticate' and 'infuse' western science with indigenous knowledge. *Journal of Education,* (74), 102-115. https://doi.org/10.17159/2520-9868/i74a07

Labone, E., Cavanagh, P., & Long, J. (2014). Critical design features of pre-service education programs to enhance teacher capacity to effectively work in schools with indigenous students. *The Australian Journal of Indigenous Education, 43*(2), 121-133. https://doi.org/10.1017/jie.2014.22

Leonard, J., Brooks, W., Barnes-Johnson, J., & Berry, R. (2010). The nuances and complexities of teaching mathematics for cultural relevance and social justice. *Journal of Teacher Education, 61*(3), 261–270. https://doi.org/10.1177/0022487109359927

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic Inquiry*. Sage

Lukmana, D., & Taha, M. (2022). An ethnography study on mathematical terminologies within two indigenous Makian languages in North Maluku. *International Journal of Trends in Mathematics Education Research, 5*(3), 228-235. https://doi.org/10.33122/ijtmer.v5i3.139

Lukong, T. (2020). African psychology or psychology in Africa: Conceptualizing education and African cultural imperialism, implications for emerging African psychologists. *Asian Journal of Education and Social Studies, 10*(2), 1-22. https://doi.org/10.9734/ajess/2020/v10i230262

MacDonald, M., Gringart, E., Booth, S., & Somerville, R. (2022). Pedagogy matters: Positive steps towards indigenous cultural competency in a pre-service teacher cohort. *Australian Journal of Education, 67*(1), 6-27. https://doi.org/10.1177/00049441221107974

Madimabe, M., Omodan, B., & Tsotetsi, C. (2022). Incorporation of indigenous knowledge in the mathematical geometry discipline at a TVET college. *Journal of Research in Mathematics Education, 11*(3), 296-312. https://doi.org/10.17583/redimat.7890

Martin, A., Ginns, P., Anderson, M., Gibson, R., & Bishop, M. (2021). Motivation and engagement among indigenous (aboriginal Australian) and non-indigenous students. *Educational Psychology, 41*(4), 424-445. https://doi.org/10.1080/01443410.2021.1879994

Matemba, Y. (2020). Decolonizing religious education in sub-Saharan Africa through the prism of anticolonialism: A conceptual proposition. *British Journal of Religious Education, 43*(1), 33–45. https://doi.org/10.1080/01416200.2020.1816529

Mawere, M. (2015). Indigenous knowledge and public education in sub-Saharan Africa. *Africa Spectrum, 50*(2), 57–71. https://doi.org/10.1177/000203971505000203

Meaney, T., & Evans, D. (2012). What is the responsibility of mathematics education to the indigenous students that it serves? *Educational Studies in Mathematics, 82*(3), 481–496. https://doi.org/10.1007/s10649-012-9439-1

Meaney, T., Fyhn, A., & Graham, S. (2021). Unfettering discussions about social justice: The role of conversational prompts in discussions about mathematics education for indigenous students. *Educational Studies in Mathematics, 109*(3), 549–565. https://doi.org/10.1007/s10649-021-10089-2

Mudaly, R. (2018a). Towards decolonizing a module in the pre-service science teacher education curriculum: The role of indigenous knowledge systems in creating spaces for transforming the curriculum. *Journal of Education,* (74), 47-66. https://doi.org/10.17159/2520-9868/i74a04

Mudaly, V. (2018b). Decolonizing the mind: Mathematics teachers explore possibilities for indigenizing the school curriculum. *Journal of Education,* (74), 67-84. https://doi.org/10.17159/2520-9868/i74a05

Mukuka, A., & Alex, J. K. (2024). Student teachers' knowledge of school-level geometry: Implications for teaching and learning. *European Journal of Educational Research, 13*(3), 1375-1389. https://doi.org/10.12973/eu-jer.13.3.1375

Mutekwe, E. (2015). Towards an African philosophy of education for indigenous knowledge systems in Africa. *Creative Education, 06*(12), 1294–1305. https://doi.org/10.4236/ce.2015.612129

Nabie, M. (2015). Where cultural games count: The voices of primary classroom teachers. *International Journal of Education in Mathematics Science and Technology, 3*(3), 219. https://doi.org/10.18404/ijemst.97065

Naidoo, J. (2021). Integrating indigenous knowledge and culturally based activities in South African mathematics classrooms. *African Journal of Teacher Education, 10*(2), 17–36. https://doi.org/10.21083/ajote.v10i2.6686

Nesterova, Y. (2019). Teaching indigenous children in Taiwan: Tensions, complexities, and opportunities. *Global Studies of Childhood, 9*(2), 156-166. https://doi.org/10.1177/2043610619846349

Nnama-Okechukwu, C. & McLaughlin, H. (2022). Indigenous knowledge and social work education in Nigeria: Made in Nigeria or made in the West? *Social Work Education, 42*(8), 1476–1493. https://doi.org/10.1080/02615479.2022.2038557

Nxumalo, S., & Mncube, D. (2018). Using indigenous games and knowledge to decolonize the school curriculum: Ubuntu perspectives. *Perspectives in Education, 36*(2), 103–118. https://doi.org/10.18820/2519593x/pie.v36i2.9

Oskineegish, M. & Berger, P. (2021). Teacher candidates' and course instructors' perspectives of a mandatory Indigenous education course in teacher education. *Brock Education Journal, 30*(1), 117. https://doi.org/10.26522/brocked.v30i1.798

Patton, M.Q. (2015). *Qualitative Research & Evaluation Methods* (4th ed). SAGE Publications.

Roorda, D., Jak, S., Zee, M., Oort, F., & Koomen, H. (2017). Affective teacher-student relationships and students' engagement and achievement: A meta-analytic update and test of the mediating role of engagement. *School Psychology Review, 46*(3), 239-261. https://doi.org/10.17105/spr-2017-0035.v46-3

Rosa, M. (2023). Considerations about ethnomathematics, the culturally relevant pedagogy and social justice in mathematical education. *Educação Matemática Pesquisa Revista Do Programa De Estudos Pós-Graduados Em Educação Matemática, 25*(2), 145-165. https://doi.org/10.23925/1983-3156.2023v25i2p145-165

Seehawer, M. (2018). South African science teachers' strategies for integrating indigenous and Western knowledge in their classes: Practical lessons in decolonization. *Educational Research for Social Change,* 7(spe), 91–110. https://doi.org/10.17159/2221-4070/2018/v7i0a7

Sianturi, M., Chiang, C., & Hurit, A. (2018). Impact of a place-based education curriculum on indigenous teachers and students. *International Journal of Instruction, 11*(1), 311-328. https://doi.org/10.12973/iji.2018.11122a

Sunzuma, G., & Maharaj, A. (2019). Teacher-related challenges affecting the integration of ethnomathematics approaches into the teaching of geometry. *Eurasia Journal of Mathematics, Science and Technology Education, 15*(9), em1744. https://doi.org/10.29333/ejmste/108457

Taylor, C. (2018). Proving in geometry: A sociocultural approach to constructing mathematical arguments through multimodal literacies. *Journal of Adolescent & Adult Literacy, 62*(2), 175–184. https://doi.org/10.1002/jaal.884

Thorpe, K. & Burgess, C. (2016). Challenging lecturer assumptions about preservice teacher learning in mandatory indigenous studies. *The Australian Journal of Indigenous Education, 45*(2), 119–128. https://doi.org/10.1017/jie.2016.20

Tracy, S. J. (2010). Qualitative quality: Eight “big-tent” criteria for excellent qualitative research. *Qualitative Inquiry, 16*(10), 837-851. https://doi.org/10.1177/1077800410383121

Wiltse, L. (2015). Mirrors and windows: Teaching and research reflections on Canadian aboriginal children’s literature. *Language and Literacy, 17*(2), 22. https://doi.org/10.20360/g2rw21

Yin, R.K. (2014). *Case Study Research: Design and Methods* (5th ed.). SAGE Publications.

Young, J., Young, J., Fox, B., Levingston, E., & Tholen, A. (2019). We would if we could: Examining culturally responsive teaching self-efficacy in a middle school mathematics methods course. *Northwest Journal of Teacher Education, 14*(1), 3. https://doi.org/10.15760/nwjte.2019.14.1.3