ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 12| Issue: 5| May 2026|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2026: 8.753 || ISI Value: 1.188

EXPLORING MATHEMATICS IN ILONGGO STRING ART: BASIS FOR THE DEVELOPMENT OF CONTEXTUALIZED LEARNING MODULE

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ABSTRACT

This study explored how local artistry could be integrated into the mathematics curriculum by identifying mathematical concepts in the string art practices of Ilonggo artists in San Miguel, Iloilo, Philippines. Despite efforts to make mathematics more relevant, there was a lack of learning materials that reflected local culture and practices. The study aimed to develop and evaluate a mathematics learning module based on Ilonggo string art to make instruction more meaningful and engaging. Using an exploratory sequential design, the qualitative phase involved interviews and observations to document string art processes and uncover embedded mathematical concepts. In the quantitative phase, developmental research methods assessed the module's acceptability in terms of curriculum alignment, cultural representation, and classroom usability. Results showed that the module was highly acceptable across all criteria, with curriculum alignment rated highest. The study concluded that local string art provides a valuable source of mathematical concepts and recommended further development of culturally relevant learning materials to enhance students' understanding and appreciation of both mathematics and local artistry.

KEYWORDS: *String Art, Contextualized Learning Module, Ethnomathematics, Spradley's Ethnographic Analysis, Philippines*

INTRODUCTION

Teaching geometry remains a persistent challenge in mathematics education, particularly due to its abstract nature and reliance on symbolic and visual reasoning. Learners frequently encounter difficulties in visualizing geometric figures, understanding their properties, and connecting these concepts to real-world contexts. Such challenges often result in superficial learning, where students rely primarily on shape recognition rather than engaging in higher-order geometric reasoning, including analysis, comparison, and deduction. Empirical evidence suggests that a majority of students remain at the lower levels of geometric thinking, with only a limited proportion demonstrating advanced conceptual understanding (Casanova, Cantoria, & Lapinid, 2021). This indicates a critical gap between intended curricular outcomes and actual student competencies in geometry.

The situation is further compounded in the Philippine context, where national and international large-scale assessments consistently report below-average performance in mathematics. Results from the Programme for International Student Assessment (PISA) 2022 reveal that only a small proportion of Filipino learners achieved baseline proficiency in mathematics, particularly in domains requiring reasoning and problem-solving. Similarly, Robles and Chua (2024) found that the majority of Grade 9 learners demonstrated low mastery (below 35%) of foundational geometry concepts, including angle relationships, properties of parallel lines, triangle inequalities, and perpendicularity. These findings highlight not only gaps in higher-order thinking but also deficiencies in foundational knowledge, underscoring the urgent need for innovative and targeted instructional interventions in geometry education.

To address these challenges, scholars have explored various pedagogical approaches such as collaborative learning, structured instruction, the Concrete–Pictorial–Abstract (CPA) approach, and spatial visualization strategies (Dimla & Soriano, 2019; Sujero, 2025; Coronado et al., 2024; Arban et al., 2025). While these approaches have demonstrated effectiveness in improving mathematical understanding, they largely remain decontextualized and insufficiently grounded in learners' cultural and lived experiences. This reveals a significant gap in the literature: the limited integration of culturally contextualized approaches in teaching geometry, particularly those that draw from indigenous knowledge systems and local practices. Despite policy support from the Department of Education, which emphasizes contextualized learning under the K–12 curriculum (DepEd Order No. 76, s. 2011), empirical studies operationalizing such approaches in mathematics instruction remain scarce.

Art integration has been identified as a promising strategy for making abstract mathematical concepts more accessible and meaningful. Eisner (2002) argues that arts-based learning enables students to engage with ideas through visual and tactile modalities, thereby facilitating deeper conceptual understanding. Within mathematics education, artistic practices can support the visualization of patterns, relationships, and structures that are otherwise difficult to grasp. One such medium is string art—a craft involving the arrangement of nails and threads to create geometric patterns. String art inherently embodies mathematical concepts such as lines, angles, symmetry, curves, and spatial relationships, offering a tangible and engaging context for learning geometry. Grabois (2016) further emphasizes that

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constructing curves and polygons through string art allows learners to explore geometric relationships dynamically, promoting both creativity and analytical thinking.

However, despite its pedagogical potential, the application of string art in mathematics education remains underexplored, particularly within culturally specific contexts. In the Ilonggo community, string art represents not only an artistic practice but also a form of cultural expression embedded with local knowledge and identity. The integration of such culturally rooted practices into mathematics instruction presents an opportunity to bridge the gap between abstract concepts and learners lived experiences. Yet, there is a paucity of research examining how indigenous or local art forms can be systematically analyzed to extract mathematical concepts and translated into instructional materials aligned with curriculum standards. Moreover, existing studies on contextualized learning often focus on general strategies without providing concrete frameworks for developing instructional materials that are both culturally responsive and pedagogically rigorous. There is limited evidence on how cultural practices can inform competency-based module development, particularly in geometry, and how such materials can be evaluated in terms of curriculum alignment, cultural representation, and usability.

Given these gaps, this study investigates the potential of Ilonggo string art as a culturally grounded context for geometry instruction. Specifically, it explores the mathematical practices embedded in the craft of local string artists and utilizes these insights to develop a contextualized instructional module aligned with curriculum competencies. By integrating indigenous knowledge, artistic practices, and mathematical concepts, this study contributes to the growing body of research on culturally responsive mathematics education and offers a novel approach to addressing persistent challenges in geometry learning.

METHODOLOGY

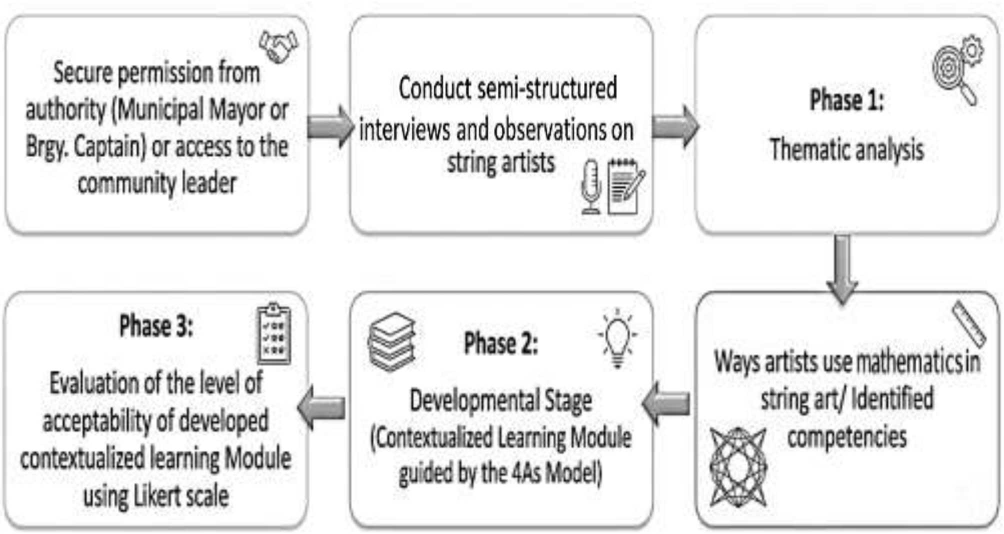
This study employed a rigorous mixed-methods approach to investigate the mathematical concepts embedded in Ilonggo string art and to develop and evaluate a culturally contextualized geometry learning module. The methodology integrates qualitative ethnographic inquiry, instructional material development, and quantitative evaluation to ensure both contextual depth and empirical validation.

Research Design

This study adopted an exploratory sequential mixed methods design, which is particularly appropriate when investigating underexplored phenomena and subsequently developing interventions grounded in empirical insights. In this design, an initial qualitative phase informs the development of materials or instruments that are later subjected to quantitative evaluation (Creswell & Plano Clark, 2018; Edmonds & Kennedy, 2022). This approach is well-suited for culturally grounded research, as it allows for the emergence of context-specific knowledge prior to generalization or validation. Despite its strengths, existing mixed-methods studies in mathematics education often prioritize either intervention effectiveness or descriptive analysis, with limited integration between cultural knowledge systems and instructional material development. This study addresses this methodological gap by systematically linking ethnographic insights with module design and evaluation within a single coherent framework.

Figure 1

Data gathering procedure map



The research was conducted in three phases. Phase 1 involved a short-term ethnographic inquiry to explore the mathematical practices embedded in Ilonggo string art. Phase 2 focused on the development of a contextualized learning module grounded in the qualitative findings. Phase 3 employed a descriptive quantitative approach to evaluate the acceptability of the developed module. This sequential structure ensured that the instructional material was both culturally authentic and pedagogically aligned.

Research Context and Participants

The study was conducted in San Miguel, Iloilo, Philippines, a locality where string art is actively practiced as both a cultural and economic activity. The selection of this site reflects the study's emphasis on situated learning and the integration of indigenous or community-based knowledge into formal education. Participants in the qualitative phase consisted of four Ilonggo string artists selected through purposive sampling. Selection criteria included: (1) active engagement in string art practice, (2) a minimum of three years of experience, (3) demonstrated skill and recognition within the community, and (4) residency in San Miguel for at least ten years. These criteria ensured that participants possessed both technical expertise and cultural immersion relevant to the study.

While the sample size is limited, it aligns with ethnographic research standards that prioritize depth of understanding over breadth. However, a common limitation in similar studies is the lack of triangulation between practitioner knowledge and instructional validation. This study addresses this by incorporating both practitioner insights and expert evaluation in subsequent phases. For the quantitative phase, 32 mathematics educators comprising department heads, master teachers, and classroom teachers served as Learning Resource Evaluators (LREs). Their expertise ensured a robust assessment of the developed module in terms of pedagogical and curricular standards.

Data Collection Methods

Data collection was conducted across three phases using multiple instruments to ensure methodological triangulation.

Phase 1: **Qualitative (Ethnographic Inquiry).**

Data were collected through semi-structured interviews, direct observations, and audio-visual documentation. Semi-structured interviews allowed for flexibility in exploring participants' experiences while maintaining alignment with the research objectives. Observations were conducted in natural settings to capture authentic practices, including design processes, material use, and pattern construction. Audio and video recordings supplemented field notes, ensuring accurate documentation of both verbal and non-verbal data. The interview guide was subjected to expert validation to ensure content relevance, methodological rigor, and alignment with research objectives. This step addressed a common limitation in qualitative studies where instrument validity is insufficiently established.

Phase 2: **Development of Instructional Material.**

Findings from the qualitative phase informed the development of a contextualized geometry learning module. Mathematical concepts identified from string art practices were mapped onto curriculum competencies to ensure alignment with national standards. The module was designed using the 4As instructional model (Activity, Analysis, Abstraction, Application), enabling a structured progression from experiential learning to conceptual understanding.

While prior studies have developed instructional materials, many lack explicit grounding in empirical cultural data. This study contributes methodologically by ensuring that the module design is directly derived from ethnographic findings rather than abstract pedagogical assumptions.

Phase 3**: Quantitative Evaluation**.

An evaluation instrument using a four-point Likert scale was administered to expert evaluators. The tool assessed three dimensions: curriculum alignment, cultural representation, and usability. These dimensions reflect both pedagogical effectiveness and cultural responsiveness, addressing a gap in existing evaluation frameworks that often overlook cultural validity

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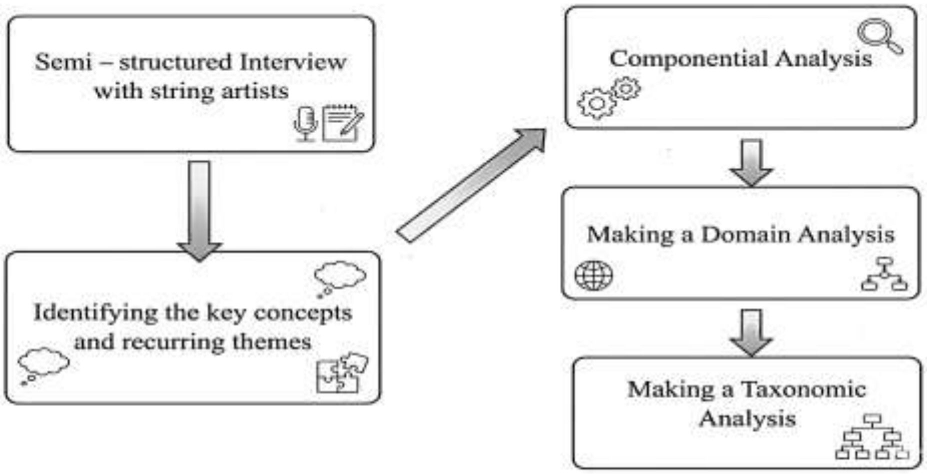
Data Analysis

Phase 1: Short-term Ethnographic

Figure 2

Spradley's ethnographic domain and taxonomic analysis (Spradley, 2006).



Qualitative Analysis. Data from interviews and observations were analyzed using selected components of Spradley's ethnographic framework, specifically domain analysis and taxonomic analysis. Domain analysis was used to identify categories of meaning within the data, while taxonomic analysis examined relationships among these categories. This approach enabled the systematic identification of mathematical concepts embedded in string art practices.

Although full ethnographic frameworks include additional analytical stages, this study adopts a focused approach to ensure alignment with its objectives. This addresses a methodological limitation in similar studies where ethnographic methods are either underutilized or applied superficially.

Quantitative Analysis. Descriptive statistics, including mean and standard deviation, were used to analyze the evaluators' ratings. The mean determined the overall level of acceptability of the module, while the standard deviation assessed the consistency of responses. A predefined scale was used to interpret acceptability levels, ranging from "not acceptable" to "highly acceptable." While descriptive statistics provide an overview of evaluation results, future studies may incorporate inferential analysis to strengthen generalizability—an identified limitation in many instructional material validation studies.

Ethical Considerations

The study adhered to established ethical standards guided by the principles of respect for persons, beneficence, and justice. Informed consent was obtained from all participants, and their participation was voluntary. Confidentiality was ensured through the use of pseudonyms and secure data storage. Given the ethnographic nature of the study, particular attention was given to cultural sensitivity and the ethical representation of indigenous practices. Participants were provided opportunities to review relevant sections of the study to ensure accurate representation of their contributions. This participatory validation process strengthens both ethical integrity and data credibility.

Trustworthiness and Rigor

The study ensured methodological rigor through strategies addressing credibility, transferability, dependability, and confirmability. Credibility was established through triangulation of data sources (interviews, observations, and documentation) and participant validation. Transferability was supported by detailed descriptions of the research context and participants. Dependability was ensured through systematic documentation of procedures, while confirmability was achieved by grounding findings in empirical data. For the quantitative component, validity was established through expert review of the evaluation instrument, and reliability was supported by the structured use of a Likert scale and consistent statistical analysis.

RESULTS AND DISCUSSION

This study examined the mathematical practices embedded in Ilonggo string art and their potential for developing a contextualized geometry learning module. The findings reveal that string art is not merely a creative activity but a structured, culturally situated practice that systematically integrates mathematical concepts such as measurement, counting, sequences, and geometric structures. These findings provide empirical support for the alignment of indigenous practices with formal mathematics competencies in the Philippine curriculum. More importantly, the results highlight a critical pedagogical insight: mathematical thinking is not exclusively developed through formal instruction but is inherently embedded in everyday cultural practices. This challenges dominant assumptions in mathematics education that position knowledge as primarily school-based and decontextualized.

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1. Embedded Mathematical Practices in String Art

1.1. Mathematics as an Implicit and Functional Practice

Findings from interviews and observations demonstrate that Ilonggo string artists consistently employ mathematical reasoning throughout the production process. Activities such as preparing materials, spacing nails, numbering points, and looping threads are guided by principles of precision, proportionality, and sequencing. For instance, artists divide the circumference or perimeter of shapes into equal parts (e.g., 300 nails) to ensure uniform spacing, reflecting implicit applications of division, ratio, and measurement. This aligns with ethnomathematics, which posits that mathematical ideas are embedded in cultural practices and everyday activities (D'Ambrosio, 2001). However, while ethnomathematics literature often documents such practices descriptively, the present study extends this by systematically linking these practices to formal curriculum competencies, thereby addressing a gap between cultural knowledge documentation and instructional application. Furthermore, the structured processes described by the informants such as numbering nails from 1 to 300 and following directional patterns (e.g., clockwise looping) indicate the presence of algorithmic thinking. This suggests that string art involves not only intuitive creativity but also procedural and rule-based reasoning, which are foundational to mathematical cognition.

1.2. Precision, Iteration, and Reflective Monitoring

A notable finding is the artists' emphasis on accuracy and continuous checking. Informants reported pausing after every 300 to 500 loops to verify alignment and correctness. This practice reflects metacognitive regulation, where individuals monitor and adjust their actions to achieve desired outcomes. From a theoretical perspective, this supports constructivist learning theory, which emphasizes active engagement and reflection in knowledge construction. The artists' iterative process such as plan, execute, check, and revise mirrors problem-solving cycles in mathematics, suggesting that authentic practices can model effective cognitive strategies for learners. However, unlike formal classroom settings where such strategies are explicitly taught, in string art these processes emerge organically through practice and experience. This highlights a gap in traditional instruction, where opportunities for authentic, iterative problem-solving are often limited.

1.3. Integration of Digital and Traditional Knowledge Systems

Another significant finding is the integration of digital tools in the creative process. Artists rely on edited images as primary references rather than manual sketches, demonstrating a hybridization of traditional craftsmanship and modern technology. This challenges the conventional dichotomy between indigenous and modern knowledge systems. Instead, the findings suggest a dynamic interaction where cultural practices evolve by incorporating contemporary tools. From a pedagogical standpoint, this has implications for designing instructional materials that are both culturally grounded and technologically relevant

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2. Thematic Mathematical Concepts and Curriculum Alignment

The analysis identified four major mathematical themes such as measurement, counting, sequences, and geometric structures, which align closely with DepEd competencies across Grade 7 to Grade 10.

Table 1

The Four Mathematical Themes in String Art Making, Including Measurements, Geometry Structures, Sequences and Counting and the Mathematical Knowledge Aligned with DepEd Mathematics Competencies in Junior High School

Theme	Traditional Knowledge	Mathematical Concepts	Dep Ed Mathematics Competencies	Grade Level
Measurements	*"Bali sir ang size sang amon nga ubra sir ang pinakagamay namon sir bali 20x20 inches, kag ang regular namon 25x25 inches kag kung ano ang gusto sang costumer kag kung ano ka dakuon ang ila ginarequest sa amon"* The string artist uses standard sizes (20×20 and 25×25 inches) and places strong emphasis on exact distance and spacing before nailing and stringing, as this stage is considered the most crucial part of the planning process prior to the execution of the entire artwork.	**Measurement** is the process of determining the size, length, amount, or value of an object or quantity by using standard units or tools. It allows people to compare and describe physical properties such as length, area, time, or weight in a clear and accurate way (Van de Walle, Karp, & Bay-Williams, 2019). The string artists use measurements to determine the size of the canvas, calculate the spacing of nails, and ensure equal distances around the edges. These measurements guide accurate nail placement and help maintain balance and uniformity in the artwork.	Converts measurements and measures length using appropriate units of measure accurately. *(M7ME-Ib-3-7)*	Gr 7

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Counting	*"Kung 300 na ka loops ang nahimo namon naga-stop guid kami anay para i-check kung may sala ukon may nasala nga spacing."* *"Mas nami nga mag-pahuway anay every 300 to 500 nga loops kaysa tapuson kag didto mo pa malantaw kung may error."* The informants explained that they deliberately pause after approximately 300 to 500 loops to inspect the alignment and detect possible errors. This practice allows them to monitor progress through counting and prevents minor mistakes from affecting the overall design.	**Counting** is the process of determining the number of elements in a set by assigning numbers in order, one for each item, to find the total amount (Burns, 2022). The artists use counting by determining the total number of nails needed for each artwork, commonly around 300 nails. They also count the nail positions and string loops as they follow the pattern, allowing them to track their progress, maintain accuracy, and ensure that each connection follows the correct order.	Uses appropriate counting techniques to determine quantities accurately, systematic counting and grouping strategies to avoid errors. *(M7SP-IIIa-3-5)*	Gr7
Sequences	*"Kinahanglan guid nga numbered ang lansang halin 1 to 300 para indi kami malipat kung diin maghalin kag diin matapos."* *"Point-to-point guid ang stringing. Kung diin ka naghalin nga numero, didto ka man maadto sa next nga ginatudlo sang number."* *"May application kami nga naga-tawag sang numero, amo na ang naga-guide sa amon kung ano nga lansang ang*	A **sequence** is a list of numbers or objects arranged in a specific order, following a clear rule or pattern, where the position of each term is important (Blitzer, 2020). The artists use sequences by numbering the nails and following a fixed order when connecting the string. They move from one nail to the next according to the given sequence, checking their progress at certain intervals to avoid errors and maintain the correct	Illustrates linear patterns and arithmetic sequences *(M10AL-IId-3-4)* Uses patterns and sequences to organize processes. *(M10AL-IId-5)*	Gr-10

	sunod nga kuwaon." The informants explained that the nails are numbered from 1 to 300 and followed through a point-to-point looping system, with some artists using voice-guided numbering to accurately follow the required sequence.	pattern in the artwork.		
Geometry Structures	"*Duwa lang gid ka porma ang akon ginaubra sa string art, either square ukon bilog. Depende na lang sa request sang customer."* *"Circumference bala sang pabilog so divide namon na may 300 bisan ano pa na ang iya nga size basta amo lang na kadamuon sang lansang nga gamiton namon so divide namon sa 300 para ma equal tanan ang spacing sang lansang"* Artist described the use of square and circular frames guided by a defined center point. They explained that both circular and square designs follow a standard process in which the circumference or perimeter is divided into 300 equal spaces to achieve uniform nail distribution.	**Geometric structures** describe the ways in which shapes, figures, and spatial relationships are formed and organized, focusing on how points, lines, planes, and angles interact to create meaningful patterns and arrangements (Jones, 2020). String artists use geometric structures by identifying basic shapes such as circles and squares as the foundation of their designs. These shapes guide the arrangement of nails, the direction of the strings, and the formation of patterns, helping create balanced and organized artworks.	Illustrates a circle and identifies its parts (center, radius, diameter). *(M10GE-IIa-1)* Apply properties and relationships of central angles, inscribed angles, chords, secants, and tangents of circles. *(M10GE-IIa-2-3)* Solves problems involving the circumference of a circle. *(M10GE-IIc-1-4)* Identifies the properties of a square and solve problems involving the perimeter of square. *(M9GE-IIa-3-4)*	Gr10 Gr9

2.1. Measurement and Proportional Reasoning

Measurement is central to string art, particularly in determining spacing and dimensions. The practice of dividing perimeter or circumference into equal segments demonstrates applied understanding of proportional reasoning and unit measurement. This directly corresponds to Grade 7 competencies involving measurement, estimation, and unit conversion.

2.2. Counting and Error Control

Counting is used not only for enumeration but also for monitoring progress and ensuring accuracy (e.g., checking every 300–500 loops). This reflects strategic counting and grouping, which are essential for developing numerical fluency and procedural accuracy.

Sequences and Pattern Recognition

The sequential connection of numbered nails illustrates pattern recognition and ordered thinking, aligning with Grade 10 competencies on sequences. The reliance on structured patterns also reinforces the importance of rule-based reasoning in mathematics.

2.3. Geometric Structures

The use of circular and square frames highlights the application of geometric concepts, including perimeter, circumference, symmetry, and spatial relationships. These practices align with competencies in Grades 9 and 10 related to geometry and properties of shapes.

While previous studies have identified these concepts in classroom settings, this study demonstrates their natural occurrence in cultural practices, thereby addressing the gap between abstract mathematical instruction and real-world application.

3. Development and Pedagogical Implications of the Contextualized Module

The contextualized learning module developed in this study translates ethnographic findings into instructional practice using the 4As model (Activity, Analysis, Abstraction, Application). This structure ensures a progression from concrete experience to abstract understanding, consistent with constructivist and experiential learning theories. The Activity phase engages learners through hands-on string art tasks, while the Analysis and Abstraction phases facilitate conceptual understanding of underlying mathematical principles. The Application phase reinforces transfer of learning to new contexts. This design reflects principles of culturally relevant teaching (CRT), which emphasizes the use of learners' cultural experiences as a foundation for instruction. By integrating Ilonggo string art, the module situates learning within a familiar and meaningful context, thereby enhancing engagement and comprehension. However, a critical observation is that while the module is theoretically robust and contextually grounded, its effectiveness in improving student learning outcomes was not empirically tested. This represents an important limitation and an area for future research.

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Learning Module 1: Geometric Structures

Lesson 1: Introduction on Circles through String Art

Subject: Mathematics
Grade Level: Grade 10
Time Frame: 1-hour 30mins

Introduction:

Circles are common geometric shapes found in everyday objects such as wheels, clocks, and coins. Learning about circles helps students understand shapes, patterns, and relationships that are important in mathematics and real-life situations.

In this module, you will study the basic parts of a circle, including the center, radius, diameter, and circumference. These concepts will help you describe and analyze circles accurately and solve related problems.

To make learning more engaging, this module integrates **string art** as a visual and creative approach. By connecting straight lines between evenly spaced points, string art forms curved patterns that resemble circles. This method helps you visualize circle properties and shows how mathematics can be connected to art.

I. Learning Competencies

At the end of the module, learners are expected to:

1. Illustrate a circle using string art.
2. Identify and label the parts of a circle: center, radius, diameter, chord, region, segment, and arcs.
3. Explain how string art represents geometric concepts of a circle.
4. Appreciate local art practices as a context for learning mathematics.

Content Standard	Performance Standard
Illustrates a circle and identifies its parts (center, radius, diameter, chord, segment, and tangent).	Learners create a simple string art design thru sketching only inspired by local practices in San Miguel, Iloilo and accurately identify and explain the parts of a circle evident in their artwork.

4. Evaluation of the Contextualized Learning Module

The quantitative findings indicate that the developed module achieved a high level of acceptability across all evaluated dimensions.

Table 2

Teachers' Evaluation of Developed Contextualized Learning Module Across Different Category (n =32)

Category	Mean	SD	Interpretation
Curriculum Alignment	3.87	0.17	Highly acceptable
Cultural Representation	3.81	0.21	Highly acceptable
Classroom Usability	3.77	0.23	Highly acceptable
Overall	3.82	0.16	Highly acceptable

1.00-1.75- Not acceptable; 1.76-2.50- Moderately acceptable; 2.51-3.25- Acceptable; 3.26-4.00- Highly acceptable

The high mean scores and low standard deviations indicate strong agreement among evaluators, suggesting that the module is both pedagogically sound and contextually relevant. From a theoretical perspective, these results reinforce the value of contextualized and culturally responsive instructional materials. The strong rating for cultural representation is particularly significant, as it addresses a common limitation in mathematics education where cultural relevance is often overlooked. Recent studies emphasize that mathematics learning materials are most effective when they are culturally relevant and connected to students' real-life experiences. Asrawati, Sappaile, and Djam'an (2024) demonstrated that modules designed using local contexts and literacy-based approaches can engage students creatively and promote critical thinking. Similarly, Aguinaldo and Domingo (2021) found that incorporating community practices and familiar activities helps learners relate abstract concepts to real-world situations, making lessons more meaningful. However, while acceptability is an important indicator, it does not necessarily equate to effectiveness. Many instructional materials are perceived as useful but may not lead to measurable learning gains. This highlights a critical gap in the current study and in similar research: the need to move beyond perception-based evaluation toward impact-based assessment.

The findings contribute to multiple theoretical frameworks:

1. Ethnomathematics – The study provides empirical evidence that mathematical knowledge is embedded in cultural practices and can be systematically analyzed for instructional use.
2. Culturally Relevant Teaching (CRT) – It demonstrates how local cultural practices can enhance engagement and understanding in mathematics.
3. Constructivist Learning Theory – The iterative and experiential nature of string art reflects core principles of active learning and knowledge construction.
4. Pragmatism – The study aligns with the view that knowledge emerges from practical engagement and real-world problem-solving.
5. Interactionism – The study highlights that learning occurs through social interaction and collaboration, where meaning is co-constructed among learners as they engage in shared cultural and mathematical activities.

More importantly, the study addresses a critical gap in the literature: the lack of methodologically integrated approaches that connect ethnographic insights with curriculum development and evaluation. By combining qualitative exploration, instructional design, and quantitative validation, the study offers a comprehensive model for developing culturally grounded educational materials. Despite its contributions, the study has limitations that must be acknowledged. The small sample size in the qualitative phase limits generalizability, although it is appropriate for ethnographic inquiry. The reliance on descriptive statistics in the evaluation phase restricts deeper analysis of differences among evaluators. Most importantly, the study does not measure the actual impact of the module on student learning outcomes. These limitations point to future research directions, including experimental or quasi-experimental studies to test the effectiveness of contextualized modules, as well as broader investigations involving diverse cultural practices.

CONCLUSION

This study demonstrates that Ilonggo string art constitutes a rich, culturally embedded practice that inherently integrates fundamental mathematical concepts, including measurement, counting, sequences, and geometric structures. Through an exploratory sequential mixed-methods design, the findings reveal that these mathematical ideas are not abstract constructs but are operationalized in the artists' everyday practices through systematic processes such as proportional spacing, sequential patterning, and iterative error-checking. This provides strong empirical support for the argument that mathematical knowledge is socially and culturally situated, reinforcing the principles of ethnomathematics and challenging the dominance of decontextualized approaches in mathematics instruction. By translating these culturally grounded practices into a contextualized learning module, the study contributes a pedagogically viable framework that aligns indigenous knowledge with formal curriculum competencies. The high acceptability ratings across curriculum alignment, cultural representation, and usability indicate that the developed module is both instructionally sound and contextually relevant. These findings affirm the value of culturally responsive teaching, demonstrating that integrating local cultural practices into mathematics education can enhance the meaningfulness and accessibility of learning. The study further advances constructivist and pragmatic perspectives by showing that knowledge emerges through active engagement with real-world practices. The structured yet experiential nature of string art reflects authentic mathematical reasoning processes, suggesting that culturally situated activities can serve as effective entry points for developing higher-order thinking in geometry. However, while the study establishes the relevance and acceptability of the contextualized module, it stops short of empirically determining its impact on learners' conceptual understanding and performance. This highlights a critical direction for future research, particularly the need for experimental validation and broader application across diverse contexts. The study contributes to the growing body of literature advocating for the integration of indigenous knowledge systems in formal education. It provides a replicable model for bridging cultural practices and curriculum standards, offering a meaningful pathway toward more inclusive, relevant, and context-sensitive mathematics education.

Conflict of Interest: The author declares no conflict of interest

Funding: This study did not receive financial support from any funding agencies.

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