DOI: https://doi.org/10.3126/pragyaratna.v6i2.70547

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Contents lists available at NepJol

Pragyaratna

A Peer-Reviewed, Open Access Journal

Bridging Cultures: Home and School Mathematics

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Article Info

Received: August 5, 2024

Accepted: September 9, 2024

Published: October 22, 2024

Abstract

Mathematics is practicing explicitly and implicitly as a part of everyday activity of different group of people. The intent of this paper is to analyze the mathematical ideas practiced in the out-of-school environment and its possible connection to the teaching and learning of school mathematics. The mathematical thinking and ideas used by the different professional groups of people, such as carvers, mason, carpenter, street venders, black smith, gold smith, shoe makers, children's games, cultural arts, cultural artefacts and household activities are limited by their workplace boundaries. Viewing their boundaries from outside, these professional groups of people is using mathematical knowledge and ideas just to perform their everyday activities. The connection of the mathematical ideas practiced in out-of-school context to the school mathematics helps students understand mathematics in effective and meaningful ways. Understanding the mathematical ideas embedded in out-of-school activities can enhance students' grasp of formal mathematics by connecting these practical experiences to academic concepts. Bridging the gap between everyday mathematical practices and school-based instruction can make learning more relevant and engaging, helping students see the real-world applications of their mathematical knowledge.

Keywords: *Culture, ethnography, ethnomathematics, implicit mathematics, school mathematics*

Introduction

This paper builds on my PhD research conducted a few years ago, which explored how implicit mathematical knowledge embedded in various student cultures contributes to the development of abstract mathematical concepts in schools. In the conclusion of the research report, I wrote a poem that reflects mathematical practices within two distinct cultural contexts: home culture and school culture (Pradhan, 2019). In the poem, the sentences with first person are my research participant and second person is outsiders of their culture.

Object is one, but their names are different
Yeah, they are same
but perceived as different
You say it is a mathematics,
and you see it as mathematics
but, I say it is my doing,
my way of living
because it's my everything
my existence and being.
Yes, I believe I am quite far,
The world where I belong
might be more bizarre,
but the stuffs that I perform
are something like those shining stars!

In fact I just don't see mathematics
I feel it
I just don't solve the mathematics
I carve it
But probably, you might not understand my way and I might not understand yours
There it is, where the conflict glows
The conflict of culture, the life which we blow
The conflict of school and home
Oh no!
We are the same
Together, lets congeal
Yeah, It's my humble appeal
Though we act as two different folds
Believe me, we make this world a shining gold,
A Shining Gold. (Pradhan, 2019)

From this poem, there are two mathematical worlds that practices mathematical ideas and concepts distinctly for their own needs in their own ways. Mathematical concepts and practices may be universal but they are expressed and understood differently across cultures. In the discussion of my research participants, they have tacit mathematical knowledge and ideas they practice for long to sustain their lives and everyday activities. In the poem, the line "I just don't see mathematics, I feel it" highlight the idea of experiential aspect of mathematics of my research participants from indigenous community. In many cultures, mathematics is not just a set of abstract concepts but something deeply rooted in everyday activities and experiences (Rosa & Gavarrete, 2017). It is not just about solving problem but about experiencing and interacting with mathematical ideas in a meaningful way. Mathematical ideas and knowledge are not passively received but actively constructed and shaped by individuals within their cultural contexts (Steffe & Kieren, 1994).

People are creating their own mathematics according to their needs, experiences, and cultural backgrounds. Each cultural environment develops its own distinct methods, styles, and techniques for doing their everyday activities and explanation for the reason essentially how and why they are doing (D'Ambrosio, 1997). Consequently, to meet the needs of survival and growth, people have developed and continue to evolve their own forms of ethnomathematics (Orey & Rosa, 2015). However, the mathematics practices in out-of-school culture are context bound. Their mathematical thinking and ideas used by the professional group of people are limited in their workplace boundaries. In mathematics education, ethnomathematics is the study of the relationship between mathematics and culture (D'Ambrosio, 2006). Viewing from the outside their boundaries, the mathematical knowledge and ideas of professional group of people are using just for the shake to perform their everyday activities. As this paper is rooted in my PhD study, it aims to bridge the gap between two distinct worlds: the home, where informal, context-bound mathematics is practiced, and the school, where mathematics is taught through structured, formalized curriculum. In this paper, the objective is to connect these two worlds, illustrating that the mathematical ideas and practices in out-of-school environments are not only valid but also valuable for enhancing the teaching and learning of school mathematics. Thus, I intended to explore the ethnomathematical ideas and knowledge rooted in the cultural context of professional group of people and looking for the bridging for the development of formal mathematics teaching and learning. The ethnomathematical ideas practicing in the out-of-school environment can facilitate the understanding of school mathematics. However, the connection of students' out-of-school mathematical ideas to classroom teaching is difficult task for most of the school teachers. The ethnomathematical ideas embedded in the everyday activities of different group of people can also be linked while teaching in classroom to make class lively.

Method and Procedures

In my research, I adopted qualitative methods to explore the intricate world of implicit mathematical knowledge among various groups and their approaches to teaching and learning within cultural contexts. Quantifying such perceptions, ideas, and knowledge through numbers and figures would not have been feasible. As Glesne and Peshkin (1992) describe, qualitative researchers are meaning makers, drawing on their personal experiences,

knowledge, and theoretical perspectives to gather data and share their interpretations. In particular, the ethnographic methodology was employed to deeply explore and understand the mathematical concepts and knowledge that are embedded within the everyday activities of different professional groups (Fetterman, 2010). This approach allowed for a thorough investigation into how these groups utilize mathematical thinking in real-life situations, often without explicitly labeling it as "mathematics." For this research, six individuals from various communities were purposefully selected to represent different professions and cultural settings, such as mason, carver, artisans, and craftsmen. These participants were chosen to shed light on how mathematics is practiced within their cultural and occupational contexts. To gather the necessary information, a combination of in-depth interviews and observations was used. The interviews provided personal insights and reflections on how these individuals apply mathematical reasoning in their daily lives, while the observations allowed for a first-hand look at how these mathematical ideas are executed in real-time. This ethnographic data revealed rich examples of how implicit mathematics functions outside formal education, often in ways that are highly sophisticated but remain unrecognized within the formal school curriculum.

After analyzing the data, I connected them with various relevant theories and literatures to interpret the findings. I employed triangulation to validate the data, theoretical insights, and ultimately give meaning to my results. Throughout this process, I aimed to produce accurate descriptions of the content. The interpretation involved attributing meaning and significance to the analysis, explaining descriptive patterns, and identifying relationships and connections between different descriptive dimensions. In my study, I examined the cultural activities of different professional groups, their understanding of natural phenomena, and their ethnomathematical knowledge through the lens of pluralism. Findings are derived by connecting the analyzed data to relevant theories, interpreting relationships, and ensuring validity through techniques like triangulation to provide accurate, meaningful conclusions.

Implicit Mathematical Practices

Implicit knowledge in the workplace encompasses the unspoken and often intangible expertise that employees develop through their daily experiences. This type of knowledge isn't usually found in manuals or formal training materials; instead, it's absorbed over time through hands-on practice, observing others, and engaging in various work situations. From an ethnomathematics perspective, implicit knowledge in the workplace can be illustrated by examining traditional craft practices. For instance, consider the knowledge of a skilled weaver in a community that produces intricate patterns on textiles. This weaver may not have formal training in geometry, but through years of practice and observation, they develop an intuitive understanding of symmetry, proportion, and spatial arrangement (Pradhan, 2019; 2023). The weaver's ability to create complex patterns involves an implicit grasp of mathematical concepts such as angles and geometric shapes. This knowledge is not documented in formal manuals but is passed down through apprenticeships and communal practices. The weaver's expertise in arranging threads to achieve specific designs reflects a deep, experiential understanding of mathematics, shaped by cultural traditions and hands-on experience rather than explicit instruction.

Implicit mathematics in a mason's workplace refers to the practical application of mathematical concepts that are often used instinctively rather than through formal calculations or explicit instruction. Masons regularly engage in tasks that require a strong understanding of geometry, measurement, and estimation, even if they don't consciously think of it as "doing math." For example, when laying bricks or stones, a mason must calculate the correct spacing and alignment to ensure that walls are straight and level. This involves understanding angles and the relationships between different shapes and sizes of materials. Masons also estimate quantities, such as the amount of mortar needed to fill gaps or the number of bricks required to complete a section of a wall. These calculations are often done quickly and mentally, based on experience and a practical understanding of mathematical principles (Pradhan, 2023). Another instance is when a mason adjusts the dimensions of a structure to fit within certain constraints, like ensuring that doorways and windows are evenly spaced or that a wall meets a specific height. This requires an understanding of ratios and proportions, even if the mason doesn't use formal equations to solve these problems. Thus, implicit mathematics in a mason's workplace is the seamless integration of mathematical reasoning into the hands-on work of building and constructing, where math is a tool used to achieve precise and functional results.

Mathematics is deeply intertwined with culture, having emerged and evolved through the daily and cultural activities of people across time. This relationship between mathematics and culture is of significant relevance and warrants close study (D'Ambrosio, 2006). Within every cultural practice, mathematical principles are inherently present, playing a crucial role in the completion of various tasks. Without these mathematical underpinnings, many of the activities that people engage in would be incomplete or impossible to perform effectively. Mathematics can be seen as a specialized language, developed to express concepts related to quantity, shape, position, and the relationships between these elements. In everyday communication, mathematical ideas are frequently utilized, often without conscious awareness. People instinctively apply mathematical reasoning to solve problems arising from their daily activities, demonstrating how deeply embedded these concepts are within human culture. Outside the formal classroom setting, individuals regularly engage with sophisticated mathematical ideas as part of their everyday lives. Whether they are aware of it or not, people apply these concepts in practical, often complex ways, reflecting the deep connection between mathematical thought and cultural practices. However, the mathematics practiced in these out-of-school contexts is often overlooked in the discussion and teaching of formal mathematics (Rosa & Gavarrete, 2017). This form of mathematics, known as ethnomathematics, encompasses the implicit mathematical ideas and practices embedded in cultural activities. In the context of this paper, various cultural practices and their associated implicit mathematical ideas are explored, highlighting the rich, yet frequently ignored, mathematical knowledge that exists within different cultural traditions. By acknowledging and understanding these practices, there is an opportunity to enrich the teaching and learning of mathematics, making it more relevant and connected to students' everyday experiences.

Ethnomathematical concepts practiced within out-of-school environments are deeply rooted in the specific contexts of the cultures in which they are found (Pradhan, 2019). For instance, the mathematical reasoning and techniques employed by skilled professionals such as carvers are typically confined within the boundaries of their respective workplaces. From an external perspective, these professional groups appear to be applying mathematical knowledge and principles solely as a means to accomplish their daily tasks. The indigenous knowledge and skills they possess are finely tuned to meet their survival needs, offering them the tools necessary to navigate and thrive within their specific cultural and environmental settings. The craft model approach is instrumental in the generation and transmission of knowledge in out-of-school cultures, where knowledge is often passed down through practical engagement rather than formal education (Pradhan, 2017).

Mathematics, in this context, is not an abstract subject disconnected from daily life, but rather an integral part of cultural practices and routines (Barton, 1996). Numerous mathematical practices can be observed in various aspects of the out-of-school environment, such as farming, local commerce, household chores, children's games, cultural arts, artifacts, and various socio-cultural events (Pradhan, 2020). For example, everyday activities in the kitchen are rich with mathematical concepts. The process of preparing tea, snacks, and meals for a family involves the application of ratios and proportions, the precise estimation of ingredients, calculations of cost, considerations of the energy required, and the timing necessary to complete the preparations. Even the simple act of observing kitchen items and their shapes offers an opportunity to conceptualize different geometric objects and mathematical ideas. The ratio of different ingredients in the preparation of tea and the various mathematical concepts embedded in kitchen practices also involve sophisticated processes of estimation and approximation.

The work performed by masons is another excellent example of sophisticated mathematical thought in practice. These artisans often employ methods like the 3-4-5 technique to construct rectangular shapes, doing so without formal knowledge of right-angle triangle properties or the Pythagorean Theorem (Pradhan, 2019). In constructing huts, for instance, members of this particular cultural group will identify the center of a rectangle by intersecting two diagonal ropes, which allows them to position the central pillar, known as the *muli khambo*, correctly. This central pillar is generally larger than the other supporting pillars because it plays a crucial role in maintaining the equilibrium of the structure, effectively balancing the gravitational forces acting upon it. The roofs of their houses and temples are often inclined at an angle of forty-five degrees, a practice that reflects a deep, albeit implicit, understanding of geometry and structural integrity. Every action they perform in the

construction process is informed by mathematical ideas, resulting in creations that are not only functional but also aesthetically pleasing. For example, the length-to-breadth ratio of their windows is often close to 1.61, which approximates the golden ratio, a proportion known for its visual harmony. Observing the various artifacts and their forms within this cultural context provides valuable insights into the conceptualization of geometric shapes and other mathematical ideas.

Estimation and approximation are essential and foundational processes in the development of mathematical concepts. A major characteristic of mathematics as practiced in the home is its reliance on these processes. People in out-of-school environments have been applying mathematical concepts implicitly for a long time, relying on their accumulated practical knowledge rather than formal education. Despite the practical validity of their mathematical ideas and knowledge, these concepts are often overlooked and remain unacknowledged in the school mathematics curriculum (Barton, 1996). Mat weavers, for example, utilize an implicit understanding of Euclidean geometry when constructing the frame for a mat. Their indigenous knowledge and skills have been refined over generations, providing them with the means to sustain themselves and continue their cultural traditions. The craft model approach serves as a primary method for generating and disseminating knowledge in out-of-school contexts, where learning is often hands-on and experiential rather than theoretical. A wide array of professional groups, including mat weavers, textile weavers, stone carvers, wood carvers, small-scale businesspeople, and others, utilize highly sophisticated mathematical ideas in their everyday activities. These practices reveal that a deep understanding of mathematics exists outside the classroom, embedded in the fabric of daily life and work. This realization leads to the conclusion that mathematics can often be taught more effectively in workplace settings, where it is directly applied and experienced, than in traditional classroom environments.

Bridging Two Mathematical Cultures: Home and School

The effectiveness and engagement of connecting two domains, such as sources and target concepts, significantly increases when the source domain is already familiar to the students. When students can relate the new information to their familiar out-of-school context and draw from their own "funds of knowledge," they are better able to grasp complex concepts. The mathematical ideas embedded in cultural arts, artifacts, and the everyday activities of various groups of people reflect a high level of sophistication in the realm of mathematics. These traditional mathematical practices, such as indigenous measurement systems, continue to exist in out-of-school environments. However, there is a significant disconnect in the way these culturally embedded practices are integrated into formal education. Many school mathematics teachers fail to utilize the rich socio-cultural diversity available to them (Acharya, 2015; Pradhan, 2019), inadvertently contributing to a process of "demathematization" that alienates students from the subject and makes mathematics seem more difficult. This observation leads to the conclusion that there is a pressing need to preserve ethnomathematical practices and to integrate them into both cultural and school mathematics curricula through innovative pedagogical approaches.

The out-of-school environment is a treasure trove of mathematical practices, observed in areas such as farming, local business operations, household tasks, children's games, cultural arts, artifacts, and social events. However, the methods of teaching and learning mathematics in formal school settings are often vastly different from those practiced in out-of-school contexts. This disparity is crucial, as it underscores the need for a more holistic approach to teaching mathematics, one that acknowledges and incorporates the mathematical practices found in students' everyday lives. This study, which focuses on bridging the gap between out-of-school environments and the teaching and learning of school mathematics, supports Zaslavsky's (1996) assertion that students benefit in two key ways: 1) they gain an appreciation for cultures different from their own, and 2) linking the study of mathematics with other disciplines and cultural contexts adds depth and meaning to the mathematical concepts being studied.

Through a review of literature and field visits, I identified several key elements that can serve as powerful tools for teaching and learning school mathematics. These include cultural artifacts, mnemonics, gestures, and the ethnomathematical ideas inherent in the activities of different groups of people (Pradhan, 2023). The

ethnographic study revealed that a vast array of mathematical knowledge is embedded in the everyday activities of various cultural groups. These activities, carried out by professional groups such as mat weavers, stone and wood carvers, carpenters, masons, and others, are underpinned by implicit mathematical ideas that enable these individuals to perform their work with great precision and skill. The study found that the mathematical concepts used in these contexts are not only sophisticated but have been passed down through generations as part of cultural traditions. These practices have been honed over time to help individuals sustain their livelihoods, demonstrating a profound and enduring connection between cultural practices and mathematical knowledge. The study's findings highlight the importance of recognizing and valuing the ethnomathematical practices that exist outside the formal school setting. These practices, which are deeply embedded in cultural traditions, offer a wealth of resources that can be leveraged to make school mathematics more relevant and meaningful. By incorporating these practices into the formal mathematics curriculum through culturally responsive and innovative pedagogy, educators can create a learning environment that resonates with students' lived experiences, fosters a deeper understanding of mathematical concepts, and preserves the cultural heritage that is an integral part of these practices.

Members of various cultural groups outside the school setting have long been applying mathematical concepts in implicit ways. Although these mathematical ideas and knowledge are practically valid, they are often overlooked or left out of the school mathematics curriculum. The ethnomathematics that thrives in out-of-school environments is typically ignored in formal classrooms. However, if these two cultural domains were integrated, students could develop a more positive attitude toward mathematics, potentially enhancing their understanding. The ethnomathematical concepts woven into the daily activities of different groups offer greater significance to the mathematics being studied and contribute to a more dynamic and engaging classroom experience. These ethnomathematical practices are closely tied to their specific cultural contexts. Implicit mathematical knowledge can be connected to culturally friendly pedagogy by integrating the real-world mathematical practices of various cultural groups into classroom instruction. Educators can draw on the mathematical ideas embedded in everyday activities, such as farming, craftsmanship, and cultural traditions, to create lessons that resonate with students' lived experiences. By recognizing and valuing these practices, teachers can design culturally relevant learning experiences that bridge the gap between students' home cultures and formal education. This approach not only makes mathematics more accessible and relatable but also fosters a deeper understanding and appreciation of the subject, while honoring the cultural heritage of the students.

Concluding Remarks

This paper emphasizes the critical role of implicit mathematical knowledge embedded in the cultural practices of various professional groups and everyday activities outside the formal school environment. These ethnomathematical practices, developed through hands-on experience and cultural traditions, represent a rich source of sophisticated mathematical ideas, such as those found in weaving, carpentry, masonry, and cultural arts. Despite the practical application of these mathematical concepts in everyday life, they are often overlooked or underutilized in formal mathematics education. Integrating the implicit mathematical practices from out-of-school environments into formal education can make mathematics more relevant and accessible to students, enhancing their understanding and engagement. By connecting these real-world experiences to academic concepts, educators can create a more meaningful and effective learning experience.

Bridging the gap between the mathematical practices of home and school cultures can enhance students' understanding by making learning more relevant and meaningful. By integrating the implicit mathematical knowledge of students' cultural backgrounds into classroom teaching, educators can preserve and celebrate these cultural practices while enriching the mathematics curriculum. This approach not only supports the development of mathematical concepts but also fosters an appreciation of cultural diversity in mathematics. The study highlights the need for innovative pedagogy that connects out-of-school mathematical practices with formal education, ultimately contributing to a more holistic and inclusive understanding of mathematics.

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