
Ethnomathematics: Connecting Cultural Aspects of Mathematics through Culturally Relevant Pedagogy

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The implementation of Culturally Relevant Pedagogy helps to develop student intellectual, social, and political learning by using cultural referents to acquire knowledge. It uses prior experiences of minority students to make learning more relevant and effective in order to strengthen connectedness with schools. Presently, there is a need to examine the embeddedness of culture in mathematics, which takes on the cultural nature of knowledge production into the mathematics curriculum. Ethnomathematics and culturally relevant pedagogy-based approaches to mathematics curriculum are intended to make mathematical content relevant to students. The objective of this theoretical article is to discuss the principles of culturally relevant education according to an ethnomathematical perspective.

Introduction

Major demographic shifts in most countries have led to increasing numbers of culturally, linguistically, socio-economically diverse, and minority students in the educational systems. For example, in the United States, the passage of the *No Child Left Behind Act* (NCLB, 2001) and the resulting requirement that all schools report disaggregated data have brought increased attention to achievement gaps that have persisted for years between minority students and their mainstream peers (Gándara, Maxwell-Jolly, & Rumberger, 2008). According to a wide range of educational indicators including grades, significant inequities continue to exist for these students' scores on standardized tests, dropout and graduation rates, and enrollment in higher education (Education Trust, 2004).

One possible explanation for these gaps may be that the disparities in achievement that stem in part from a lack of fit between traditional

schools, in which practice is derived almost exclusively from Western cultures, and the home cultures of minority students. Learners whose cultural backgrounds are rooted in Western ways of thinking possess an innate educational advantage as compared to students from alternative social cases and other cultural backgrounds. In this regard; minority students are required to learn through cultural ways of thinking and practices other than their own (Rosa, 2010).

In the last three decades, theories of culturally relevant pedagogy and ethnomathematics were developed in order to ease sociocultural concerns. The terms culturally relevant pedagogy (Ladson-Billings, 1995) and culturally responsive pedagogy (Gay, 2000) are often used interchangeably. However, we prefer to apply the term *culturally relevant* as it combines an examination of the cultural and socioeconomic influences on the process of teaching and learning mathematics. As well, it includes knowledge along with a commitment to the challenging of social injustices and reflections upon educational challenges by identifying obvious and subtle individual, institutional, and cultural actions that perpetuate social structures. The overall goal of these theories is to empower students through learning activities that help them to develop their literacy, numeracy, technological, social, and political skills in order to be active participants in a democratic society. It is also important to emphasize that a culturally relevant pedagogy studies the cultural congruence between the cultural backgrounds of students, communities, and schools, which form one the principals of an ethnomathematics program. In relation to the pedagogical work in schools, mathematical curricular activities must be relevant to the students' cultural backgrounds.

The views of pedagogy within the literature on ethnomathematics are compatible with work on culturally relevant pedagogies (Hart, 2003) because they examine the cultural congruencies between the community and school. This means that cultural congruence indicates the teachers' respect for social, cultural, and linguistic backgrounds of their students. However, it is equally necessary that school leadership and teachers acquire the knowledge of and respect for the various cultural traditions, languages, and mathematical knowledge of their students so they are able to implement the principle of cultural congruence in schools and classrooms (D'Ambrosio, 1990). On the other hand, since mathematics usually tends to be presented as a set of objective and universal facts and rules, it is viewed as *culture free* and not considered a socially and culturally constructed discipline.

To change this perception, it is necessary that curriculum developers and teachers take into account what counts as mathematics and how this knowledge itself may be related to the norms and values of diverse cultures (Rosa, 2010). If as educators we come to integrate the diverse cultures we encounter in our school communities, then there is a need to create a conceptual framework to make coherent decisions regarding these curricular activities concerning the mathematics curriculum.

In this regard, the aim of this paper is to show the need to examine the ethnomathematical perspective where-in the embeddedness of mathematics in all cultures takes on the cultural nature of knowledge production into a mathematics curriculum. The argumentation is that culturally relevant pedagogies may be considered as an ethnomathematical approach to the development of a mathematics curriculum because they intend to make school mathematics relevant and meaningful regarding the promotion of the overall quality of students' educational experience.

Culturally Relevant Pedagogy and Ethnomathematics: Curricular Implications

An important change in mathematical instruction needs to take place in order to accommodate continuous and ongoing changes in the demographics of students in mathematics classrooms. It is necessary to integrate a culturally relevant pedagogy into the existing mathematics curriculum because it proposes that teachers contextualize mathematics learning by relating mathematical content to students' real life-experiences.

The guidelines of both the National Council of Teacher of Mathematics (NCTM, 1991) and the Brazilian Ministry of Education and Culture (Brasil, 1997) highlight the importance of building connections between mathematics and personal lives and cultures of students. Along with this line, when practical or culturally-based problems are examined in a proper social context, the practical mathematics of social groups is not trivial because they reflect themes that are profoundly linked to the daily lives of students (Rosa & Orey, 2007). In this perspective, students may be successful in mathematics

when their understanding of it is linked to meaningful cultural referents, and when the instruction assumes that all students are capable of mastering the subject matter (Ladson-Billings, 1995) such as mathematics.

Curricular activities developed according to principles of culturally relevant pedagogy focus on the role of mathematics in sociocultural contexts that involve ideas and procedures associated with ethnomathematical perspectives to solve problems. The mathematics knowledge found in a culturally relevant pedagogy is perceived as a version of ethnomathematics because *ethno* is defined as culturally identifiable groups with their jargons, codes, symbols, myths, and even specific ways of reasoning and inferring; *mathema* is defined as categories of analysis; and *tics* is defined as methods or techniques for solving problems faced daily. In a culturally relevant mathematics classroom, teachers build from students' previous knowledge (*ethno*) and direct the lessons toward their culture and experiences (*mathema*) while developing critical thinking skills (*tics*) (Rosa, 2010).

The inclusion of cultural aspects in a mathematics curriculum has long-term benefits for student mathematical attainment because these aspects contribute to recognizing that mathematics is part of our daily lives and deepen the understanding of its nature by enhancing students' ability to make meaningful connections. Thus, pedagogical work towards an ethnomathematics perspective allows for a broader analysis of school contexts in which pedagogical practices transcend classroom environments (Rosa, 2010).

Therefore, ethnomathematics presents possibilities for educational initiatives and new curriculum objectives because it is a research program that guides educational pedagogical practices. However, the incorporation of the objectives of a pedagogical action of an ethnomathematics program is a recent field of study that is developing its own identity in mathematics education (Rosa & Orey, 2007). Thus, a dilemma regarding this issue is how to prepare teachers to elaborate curriculum activities based on culturally relevant pedagogy and ethnomathematics (Greer, 2013).

The trend towards ethnomathematical approaches in mathematics curriculum development and culturally relevant pedagogy initiatives reflect a comprehensive development in mathematics education. Ethnomathematical approaches are intended to make school mathematics more relevant and meaningful to students in order to promote

the overall quality of education; and to plead for more culturally relevant views of mathematics. For example, it is important to elaborate mathematics curricula that are based on the previous knowledge of students, and which allows teachers to have more freedom and creativity (Powell & Frankenstein, 1997). In this context, it is necessary that teachers value the diverse home cultures of students by explicitly addressing curricular connections to the previous knowledge they bring to school. In this approach, teachers need to teach mathematics in a culturally appropriate manner situated within students' funds of knowledge in order to underscore connections to their home culture and use them to scaffold learning (Moll, Amanti, Neff, & Gonzalez, 1992).

The application of culturally relevant pedagogy and ethnomathematical perspectives in classroom validates and incorporates students' cultural background, ethnic history, and current societal interests into teachers' daily instruction. It addresses students' socio-emotional needs and uses ethnically and culturally diverse materials for its pedagogical action in classrooms (Gay, 2000). In this regard, culturally relevant pedagogy is an educational approach that empowers students intellectually, socially, emotionally, and politically through the use of sociocultural and historical references to convey knowledge, imparts academic skills, and change students' attitudes towards academic instruction (Ladson-Billings, 1994).

This pedagogical approach is achieved through dialogue when community members, teachers, and students discuss mathematical themes that help them to reflect about problems that are directly relevant to their community. In this context, students investigate conceptions, traditions, and mathematical practices developed by members of distinct cultural groups in order to incorporate them into the mathematics curriculum. Teachers learn to engage students in critical analysis of the dominant culture as well as the analysis of their own culture.

We would like now to share one example of how teachers might investigate a common object and integrate this investigation into the school curriculum. We chose quilts here, as they are common folk-art traditions in both Brazil and the United States and because both countries have sizeable Afro-American populations who have made many contributions to cultural developments and in both countries.

Symmetrical Freedom Quilts: A Culturally Relevant Activity Based on an Ethnomathematical Perspective

Throughout time, quilts have been created as a vehicle for sharing family history, a moral message, or as a reflection of important historical and cultural events. Quilts may be considered as cultural, artistic, and mathematical expressions and manifestations of mental models that represent a specific cultural activity. One example of this representation was related to the life of slaves in the United States and Brazil. In this activity we explore the symmetrical patterns found in specific quilt patterns in the United States known as *freedom quilts*, as well, the connections between culturally relevant pedagogy, ethnomathematics, and the tactile craft and art of quilting (Rosa & Orey, 2012).

The study of quilts made by people who endured slavery in the US provides an opportunity to study its history from perspectives that are not well represented in history books. Fabrics used, designs constructed, and stitches made tell stories about the terrible oppression, suffering, and resilience of African-Americans living in that time period. Symmetrical freedom quilts were the physical traces (cultural artifacts) of a people who made a community around the creation of the quilts that expressed their shared hopes, values, and beliefs. In this sense, quilt making was a collective response to their human experience and suffering (Rosa & Orey, 2012).

The story of symmetrical freedom quilts offers a mixture of fact and myth. Its oral tradition may not give us accurate information, but it reflects a greater truth inherent in the pride of the members of this specific cultural group (former slaves). It could be that there was no real role of symmetrical freedom quilts in the Underground Railroad during slavery in the US, as there are numerous debates related to if quilts were really used as directional codes in helping slaves to escape. According to Rosa and Orey (2012), whether or not the story of the symmetrical freedom quilts is true, or it is myth, it is an appealing story and has touched the hearts of many, and presents us with a story with mathematical potential.

The focus of this project is on one important form of communication as used on the *Underground Railroad* by African-Americans

who were escaping slavery. This term has come to us from a story of a farmer chasing a runaway who testified that this slave vanished as if they had left on some kind of *underground railroad*, which was used to describe the network of abolitionists and safe houses that helped slaves escape north to Ohio and Canada. Safe houses along the way were known as *stations*, and those who guided the escapees were called conductors and the runaways themselves were called *passengers* (Burns & Bouchard, 2003).

What it is known is that the *Underground Railroad* was organized by former slaves, freed blacks, and sympathetic whites for the slaves to find shelter, food, drinking water, safe hiding places, and safe paths to follow as they moved to the free states of the north and into Canada. The quilts are referred to as *Freedom Quilts* and they were often hung over a clothes lines, on porches, windowsills, and balconies to signal what to do or where to go by using different designs that indicated directions, safety, danger, clues, and landmarks to guide the slaves to freedom.

The quilts were sewn to serve as coded messages for runaway slaves to memorize. Since most slaves were not taught to read or write in English, they developed an intricate system of secret codes, signs, and signals to communicate with one another along the escape routes. In order to memorize the whole code, a sampler quilt was used, which included all the necessary patterns arranged in the order of the codes they needed to know. Freed slaves traveled from one plantation to another to teach other slaves the patterns and designs and the translation of codes in the sampler quilt patterns (Wilson, 2002).

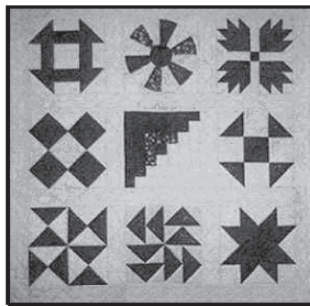


Figure 1: Ozella's Underground Railroad Symmetrical Freedom Sampler Quilt

Knot-making was also a practice that has an interesting historical background from Africa. Knots were tied in the quilts to encode objects with meaning, messages, and protective power. It is possible then that symmetrical freedom quilts contained ties with knots that were often used to indicate the dates and times for slaves to run away or meet from their working plantation. For example, five knots in the cord meant that they should escape on the 5th hour of the 5th day of the 5th month. As well, if a quilt showed a house with smoke coming out of the chimney it meant that the house was safe (Wilson, 2002) for shelter.

This method of communication was very effective because bounty hunters apparently never caught onto the quilts and their messages (Rosa & Orey, 2012). Symmetrical freedom quilts presented an ingenious, indeed highly creative, and complex way in which to communicate between slaves and safe houses because they did not show any overt connection to slavery (Rosa & Orey, 2012). These quilts may have played a key role in the ending of slavery in the United States, however we do understand that there is little to no corroborating scientific and historical evidence that support these ideas.

The main objective of an ethnomathematical perspective of this context is to understand and comprehend mathematical practices developed by the members of this specific cultural group in the course of dealing with problems faced in their daily lives (D'Ambrosio, 1990). The quilt codes may be considered as mathematical techniques (tics) used by the slaves (ethno) who were trying to manage the problems and activities that arose in their own social and political environments (mathema). These codes were transmitted to relatives of the slaves to their ancestors and across generations (Rosa & Orey, 2012).

The use of culturally relevant pedagogy values the previous knowledge of the members of a given cultural group such as former slaves by developing the process of elaborating mathematical procedures in its different contexts such as political, social, economic, and environmental. In this regard, the mathematics practiced and elaborated by the members of distinct cultural groups, and involves the mathematical practices that are present in diverse situations in the daily lives of members of these diverse groups.

Mathematizing ideas involves connecting the informal mathematics developed in a given cultural group to formal mathematical concepts by using ideas, procedures, and mathematical practices that

are used by the member of specific cultural groups. In this context, symmetrical freedom quilt designs such as Shoo Fly quilt block contain geometric concepts like symmetry, similarity, congruence, translations, rotations, and reflections (Rosa & Orey, 2012).

In the context of culturally relevant pedagogy, students can be successful in mathematics when their understanding of it is linked to meaningful cultural referents (Ladson-Billings, 1995). According to this perspective, Shoo Fly is one the simplest traditional patterns. Although Shoo Fly is a basic pattern, its versatility provides quilters with opportunities for creative use of colors, fabrics, and stitching.



Figure 2: Shoo Fly symmetrical quilt block

For example, students mathematize a point of reflection of the Shoo Fly quilt block, which is determined when a figure is built around a single point called its center. For every point in the figure, there is another point that is found directly opposite on the other side of the figure. While any point in the x - y coordinate system may be used as a point of reflection, the most common point used is the origin. In the *Shoo Fly* quilt block, the point of reflection is at the origin of the x - y coordinate system.

By applying the general mapping of transformations in the three points of reflection in the triangle below it is possible to find their images, which are . In this specific case, triangle $A'B'C'$ is the image of triangle ABC after a reflection on the origin of the Cartesian coordinate system. Figure 6 shows the point of reflection of the Shoo Fly quilt block at the origin of the x - y coordinate system.

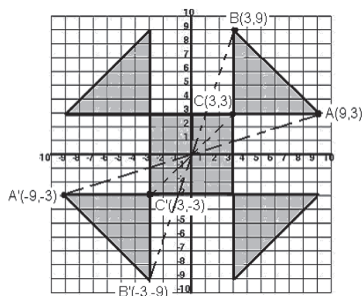


Figure 3: Point of Reflection of the Shoo Fly quilt block at the origin of the x-y coordinate system

The point of reflection is also called the point of symmetry. In a point of symmetry, the center point is a midpoint to every segment formed by joining a point to its image. The three straight dashed lines that connect A to A' , B to B' , and C to C' pass through the origin, which is the midpoint of each line segment. A figure that has point symmetry is unchanged in appearance after a 180° rotation.

Final Considerations

It is important to emphasize that this kind of curriculum may motivate some students to recognize mathematics as part of their everyday life and can enhance students' ability to make meaningful mathematical connections by deepening their understanding of all forms of mathematics. For example, Duarte (2004) investigated the uniqueness of mathematical knowledge produced by workers in home construction industry through the study of mathematical ideas and practices they developed in construction sites. In this study, there was a reflection on the mathematical knowledge possessed by the members of this working class to academically legitimize their knowledge in order to determine the pedagogical and curricular implications that were inferred in the process of production of this knowledge.

The objective of developing an ethnomathematical curriculum model for classrooms is to assist students to become aware of how people mathematize and think mathematically in their culture, to use this awareness to learn about formal mathematics, and to increase their

ability to mathematize in any context in the future. This kind of curriculum leads to the development of a sequence of instructional cultural activities that enable students to become aware of potential practices in the mathematics in their culture so that they are able to understand the nature, development, and origins of academic mathematics. Students also value and appreciate their previous mathematical knowledge, which allows them to understand and experience these cultural activities from a mathematical point of view, thereby, allowing them to make the link between school mathematics and the real world. An ethnomathematical curriculum helps students understand the nature of mathematics because it presents us an effective tool that can contribute the learning of mathematics of students (Rosa & Orey, 2007).

The integration of ethnomathematics and culturally relevant pedagogy into the mathematics curriculum focuses on the development of this research area as a process, rather than a collection of facts because it is based on the idea that mathematics is a human creation that emerges as people attempt to understand and comprehend the world around them. Therefore, mathematics can be seen as a process as well as a human activity rather than just as a set of academic content (Rosa, 2010). The implication of this kind of curriculum is not just about the application of relevant contexts in learning and teaching mathematics, but is also about generating formal mathematics from cultural ideas.

Mathematics knowledge in the context of culturally relevant pedagogy can be perceived as an ethnomathematical perspective because teachers build from the students' informal mathematics and orients the lesson toward their culture and experiences, while developing their critical thinking skills. In this context, students are considered as a culturally identifiable group with their own jargons, codes, symbols, myths, and specific ways of reasoning and inferring (ethno) who develop their own categories of analysis (mathema) and apply specific methods or techniques to solve problems faced daily.

Since ethnomathematics studies the cultural aspects of mathematics and presents the mathematical ideas, procedures, and practices of the curriculum in a way that is related to student cultural backgrounds by enhancing their ability to make meaningful connections and deepening their understanding of mathematics. This perspective matches teaching styles to the culture and home backgrounds of their students, which is one of the most important principles of culturally relevant pedagogy.

Here we have offered a brief example of how ethnomathematics can be used to link diverse ways of knowing and learning and culturally embedded knowledge with academic mathematics. Quilt exploration allows learners to explore the rich academic and culturally rich traditions diverse populations. Teaching mathematics through cultural relevant and ethnomathematical perspective helps students to know more about reality, culture, society, environmental issues, and see mathematics in the world around them. By providing students with mathematical content and approaches that enable them to successfully master academic mathematics, an ethnomathematics approach to the mathematics curriculum is considered a pedagogical vehicle for achieving such a goal.

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