Chapter 18
Using Ethnomathematics Perspective to Widen the Vision of Mathematics Teacher Education Curriculum

Nirmala Naresh and Lisa Kasmer

Abstract In this chapter, we draw upon our collective professional and practical knowledge bases to describe our efforts in fostering connections between ethnomathematics theory and practice. The theoretical field of ethnomathematics empowered us to envision a dynamic and equity-oriented teacher education curriculum. The enactment of this curriculum enabled us to create spaces wherein prospective teachers came to bear on the significance of teaching mathematics to promote a more just and democratic agenda. Prospective teachers explored and promoted meaningful connections between mathematics content, context, culture, and society in order to promote the development of empathy, consideration, and the skills necessary to appreciate and educate all learners, in particular those that are marginalized because of their social, cultural, economic, and political backgrounds.

Introduction

> Academic mathematics education has failed for the majority of the people. This failure is due in part to the conventional portrayal of mathematics as a prized body of knowledge that is the property of an elite group of people. (Millroy, 1992, p. 50)

Traditionally, mathematics education has mostly been associated with the K–12 institutional context. The problem is that mathematics in school settings is mostly perceived and presented as an elite body of knowledge stripped of its rich social, cultural, and historical connections. It is far removed from the "lives and ways of living of the social majorities in the world" (Fasheh, 2000, p. 5). We contest this view and argue for countering a narrow vision of mathematics that confines it to the school.

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When thinking about mathematics, seldom does one consider culture, context, diversity, history, or politics (D'Ambrosio, 1985; Powell & Frankenstein, 1997; Zaslavsky, 2002). Traditionally mathematics has been taught from a narrow perspective, and this has resulted in the omission of "significant contributions of most cultures and other groupings of people" from academic mathematics curricula, and this exclusion can "have the consequence of devaluing and disrespecting many students' cultural backgrounds" (Mukhopadhyay, Powell, & Frankenstein, 2009, p. 65).

One way to address this issue is through teacher education, using it as a space to transform a traditional mathematics curriculum and thereby to challenge many prospective teachers' traditionally held perceptions of mathematics and its pedagogy. The constructs of a culturally responsive mathematics education (CRME) (Gay, 2000) and a critical ethnomathematics curriculum (CEC) (Mukhopadhyay et al., 2009) lend themselves well to this cause. For a truly transformative mathematics education, it is imperative that we continue to engage with and support teachers who are in a strong position to realize the goals of a CRME in K–12 mathematics classrooms. In this chapter, we describe ways in which we used tenets of a CEC within two teacher education courses to promote an awareness of the importance of attending to the social and cultural dimensions of mathematics education.

Positionality

An educator's pedagogical decisions and actions are greatly informed and influenced by their personal, practical, and professional experiences (Kitchen, 2009). In light of this, we situate this paper in the broader context of our personal and professional backgrounds. Having been born and raised in a metropolitan city in a developing and formerly colonized nation, the first author's school and college mathematics learning experiences were rooted in an imported curriculum that was devoid of any connections to the local context and culture. In retrospect, there was also a noticeable paucity of attention to the significance of and connections to culture, language, and context in the second author's undergraduate and graduate learning experiences. Such experience perpetuates among many learners a narrow perception of mathematics that limits their ability to perceive and present mathematics as a human activity.

Through our collective mathematical learning and teaching experiences, we have witnessed firsthand how educational institutions used mathematics as a "subtle weapon" to "monopoliz[e] what constitutes knowledge" (Fasheh, 2012, p. 94). Our perceptions and beliefs about mathematics and its pedagogy prevailed until we began a self-study (Arizona Group, 1998) focused on ethnomathematics and its pedagogy, which proved both an immersive and transformative learning experience during which we became ardent enthusiasts of ethnomathematics and its theoretical and practical implications. Embracing an ethnomathematics perspective has opened our eyes to a world of mathematics that exists and flourishes outside the rigid boundaries of academia. Beyond that, it has enabled us to develop a renewed perception of mathematics and its pedagogy, its status in the society, and the role that it can play in the advancement of mankind. We have come to realize that mathematics is a human endeavor and developed a "respect for the 'other' and the intellectual achievements of all" (Mukhopadhyay et al., 2009, p. 4). This perspective has deeply impacted both our teaching and research and has pushed us to re-envision the ways in which we enact these practices.

Theoretical Underpinnings

The research field of ethnomathematics serves as a broader theoretical base on which a critical mathematics curriculum rests. Ethnomathematics represents a view of mathematical thinking that incorporates the ways in which culture and mathematics are intertwined (D'Ambrosio, 1985). Definitions of the term ethnomathematics range from very specific, such as "the mathematics which is practiced among identifiable cultural groups such as national, tribal societies, labor groups, children of certain age brackets, and professional classes" (D'Ambrosio, 1985, p. 45), to very broad: "Ethnomathematics is a research programme of the way in which cultural groups understand, articulate and use the concepts and practices which we describe as mathematical, whether or not the cultural group has a concept of mathematics" (Barton, 1996, p. 214). A grave concern with the exclusion of marginalized groups such as women, and racial and ethnic minorities from the mainstream mathematics curriculum resulted in researchers studying the ethnomathematics of these groups. Thus, issues of social change, equity, and justice have served as a foundation for the development of ethnomathematics.

Broadly speaking, we can classify ethnomathematics research into four strands (Vithal & Skovsmose, 1997): (1) a study of *non-Western mathematics*, which emphasized contributions from researchers who challenged the traditionally told history of mathematics (e.g., Joseph, 1987; Selin, 2000); (2) an exploration of *multicultural mathematics*, through which researchers analyzed mathematics associated with little-known exotic cultures and groups of people (e.g., Ascher, 2002; Gerdes, 2010; Zaslavsky, 1998); and (3) documentation of *everyday mathematics*, which highlighted the mathematical practices of participants in everyday settings (e.g., Carraher, Carraher, & Schliemann, 1987; Lave, 1988, Millroy, 1992). The fourth strand articulates the implications of ethnomathematics for school mathematics education (e.g., Brenner & Moschkovich, 2002). Though the terms *ethnomathematics*, *everyday mathematics*, and *multicultural mathematics* have been interpreted in more than one way by researchers, they are guided by the belief that the role of culture is significant in the learning and teaching of mathematics.

Mukhopadhyay and colleagues expand the scope of ethnomathematics to include mainstream academic mathematics and school mathematics. From this perspective "ethnomathematics is not proposed, as is often believed, as an alternative to either academic mathematics or school mathematics" but could coexist and thrive within the realms of academia (p. 70). We adopt this approach and in this chapter explicate connections between various strands of ethnomathematics to address this question:

How can we use the tenets of ethnomathematics to develop an increased awareness among educators of the significance of a culturally responsive mathematics education and thereby address the needs of all students, in particular those that are marginalized in the mathematics classroom?

Marginalized students are those students who are considered to have low socioeconomic status and/or students whose cultural and linguistic backgrounds are different than their White peers (Garcia & Guerra, 2004). A traditional mathematics curriculum offers teachers very little scope to understand, appreciate, and view these students and their backgrounds as rich sources of mathematical knowledge. Thus, many teachers treat "such students as blank slates, ignoring potential new strategies, conceptual understandings or unique algorithms that they could offer in a U.S. mathematics classroom" (Gutiérrez, 2008 p. 361).

We propose that an ethnomathematics curriculum with a critical perspective will help address this issue and generate a meaningful dialogue centered on a CRME (Gay, 2000), aimed to empower and transform all learners. The key tenets of a CRME include (1) helping students connect academic mathematics to other forms of mathematics, (2) connecting school mathematics to the sociocultural-ethnical aspects of home culture, (3) enabling teachers with equitable pedagogical practices that cater to all learners, and (4) allowing both students and teachers to acknowledge and celebrate their own and each other's cultural background (Gay, 2000). A CEC draws on the principles of a CRME and addresses the challenges that it poses to a traditional mathematics curriculum. It challenges the "Eurocentric narrative," confronts "what counts as knowledge in school mathematics," and attends to the disconnect between "mathematics education and social and political change" (Mukhopadhyay et al., 2009, p. 72). In order to accomplish these goals, it is necessary to design and enact a curriculum that will offer the maximum scope to empower all learners by broadening their perspective of mathematics and its pedagogy. We draw upon our collective, professional, and practical knowledge to describe ways in which we used key aspects of a CEC to support preservice teachers (PSTs) in making meaningful connections between mathematics content, context, culture, and society.

Self-Study Using Narrative Inquiry Methods

We share a common commitment to improving our own practice as mathematics teacher educators and in particular as ethnomathematics researchers and practitioners. To honor this, we engaged in a self-study with an emphasis on collaborative learning. This approach helped focus the lens on our "own selves" and enabled us to maintain focus on a more "diverse variety of selves." Within the self-study, we have used narrative inquiry (Creswell, 1998; Kitchen, 2009) to organize, present, and analyze the qualitative data. In choosing this method, we "adopt a particular view of experience as phenomenon under study" (Connelly & Clandinin, 2006, p. 375). In the present context, we draw from our practical and professional experiences specific to two content courses for PSTs (phenomenon under study), immerse ourselves in these lived experiences, and narrate our stories. The stories were extracted from two distinct professional experiences aimed to challenge and broaden PST views of mathematics and teaching through (1) content-focused coursework offered in an on-campus setting and (2) an immersive early field experience facilitated in a non-Western developing country.

The two teacher education courses shaped the contextual setting, and the PSTs enrolled in these courses are an integral part of the study. In our narratives, we consciously chose and presented data that would best help us address the central goal of this chapter and involve the "selves" who we wanted to know more about. The selves include both MTEs (us) and PSTs (our students). PST-contributed data include their solutions to mathematical tasks (SMT), course project artifacts (CPA), written reflections (WR), and summaries of their field experiences with middle school students (FE). MTE-contributed data include positionality statements (PS) and personal philosophies of teaching (PPT), course artifacts (CA), summaries of our interactions with PSTs (SI), collaborative reflective journals (CRJ), and a shared understanding and analyses of PST-contributed data (UA). Our narratives are structured around a chronology of events, including (a) course design and enactment, (b) documentation of data, and (c) our analyses and interpretation of data in relation to the chosen theoretical domain. In our narratives, we consciously choose and present data and episodes from our professional and practical experiences that will best help us attend to the central theme of this paper.

University A: Content-Focused Coursework

The contextual setting for University A is a mathematics content course, *Patterns and Structures through Inquiry* (*PSI*), for PSTs. This is a three credit-hour (38 contact hours) course for PSTs pursuing licensure to teach middle school mathematics. PSTs typically enrolled in this capstone course in their fourth year at the university. Prerequisites for this course include successful completion of at least 9 hours of mathematics education courses that address topics such as numbers and operations, algebra, geometry, technology, and the history of mathematics.

PSI Course: Goals, Content, and Structure

This course is designed to foster critical thinking, engage PSTs in solving complex problems and with other learners, and facilitate PSTs' communication of their mathematical ideas. The first author chose *ethnomathematics* as the focus theme. To this end, the key course goals were to support PSTs' examination, from sociocultural, critical, and political standpoints, of the evolution of mathematical ideas. The PSI course was designed in line with the principles highlighted in Presmeg's (1998) graduate course on ethnomathematics. Presmeg's course required participants to (a) adopt a sociocultural and a critical approach to view mathematics and its pedagogy; (b) acknowledge and understand that different cultural groups and people in many walks of life do, perceive, and explain mathematics; and (c) complete a course project to design and accentuate an ethnomathematical activity specific to their unique cultural background. The first author, having had an opportunity to participate in such a course, saw firsthand a practical application of ethnomathematics theory in an MTE course and its transformative effect on the participants. As an ethnomathematics researcher and practitioner, when provided an opportunity to teach a capstone course, the first author readily embraced and adopted the principles of Presmeg's ethnomathematics course in the design and enactment of the PSI course.

In the PSI course, PSTs engaged in problem-solving activities in small groups and shared their work with peers through formal and informal presentations. To establish specific connections to the principles of ethnomathematics and a CRME, participants were asked to think deeply about the types of tasks and activities that are usually presented in a traditional mathematics curriculum by comparing and contrasting such tasks with those that were presented in the PSI course. For example, while focusing on the algebra strand, particularly on pattern recognition and analysis, three tasks chosen from different cultural and historical contexts were presented to the PSTs: (a) the classic rice and the chessboard problem, (b) analyzing Kolam patterns of South Indian women (Siromoney, 1978), and (c) Sona patterns of the Chokwe people (Gerdes, 1997). In their written solutions to such tasks, PSTs were asked to attend to and explore the connections between a given mathematical task and the local and global contexts that framed the tasks (SMTs). Each week, PSTs were asked to describe and reflect on their perceptions of mathematics and articulate their beliefs on what constitutes a mathematical activity (WRs). The first author met each participant once a week to discuss coursework, learn more about their views on mathematics and the teaching of mathematics, and their emergent views on the role of culture in the teaching and learning of mathematics based on which we wrote my SIs. Course activities can be broadly classified into two major categories: (a) content explorations (emphasis: local/global contexts and cultures) and (b) course project investigations (emphasis: connections between everyday mathematics and academic mathematics). Below, we highlight two activities drawn from course artifacts.

Activity 1: Teaching Geometry Using Cultural Artifacts

For content analysis, participants (re)examined mathematical topics that typically lie outside the focus of the traditional K–8 mathematics curriculum. The tasks were chosen to enable PSTs to make explicit connections to the sociocultural, historical, and political dimensions of the evolution of mathematics. As part of content explorations on geometry, the following activities were planned and offered: (a) creating a timeline for the evolution of geometry (Lumpkin, 1997), (b) investigating the Sona geometry of Chokwe tribes (Gerdes, 1997), and (c) exploring geometry and technology through Native American cultural artifacts (Eglash, 2002).

A bead loom, which is used by many ethnic groups, including many Native Americans, can be viewed as a pattern based on a Cartesian coordinate system and can be used to explore transformational geometry. We used the cultural artifacts (bead patterns) with our PSTs to support them in thinking deeply about the Native American cultural context and the mathematical content implicit in the artifacts. Using Virtual Bead Loom software (Eglash, 2002), PSTs replicated bead loom patterns while at the same time making connections to their knowledge of symmetry and transformations. To ensure a successful enactment of the lesson, we suggested the following steps: (1) visit https://csdt.rpi.edu/culture/legacy/index2.html, identify and select the Virtual Bead loom tool, (2) read the cultural background section to better understand the significance of the bead loom in Native American culture, (3) read the "how-to" overview to understand the function and purpose of the different bead loom tools (point, line, line iteration, triangle iteration, rectangle iteration) and how they work, (4) choose a bead loom pattern and use appropriate tools to replicate this pattern, and (5) write a brief summary describing the steps that you used to replicate this pattern. Two sample PST responses are highlighted here (SMTs, Figs. 18.1 and 18.2).

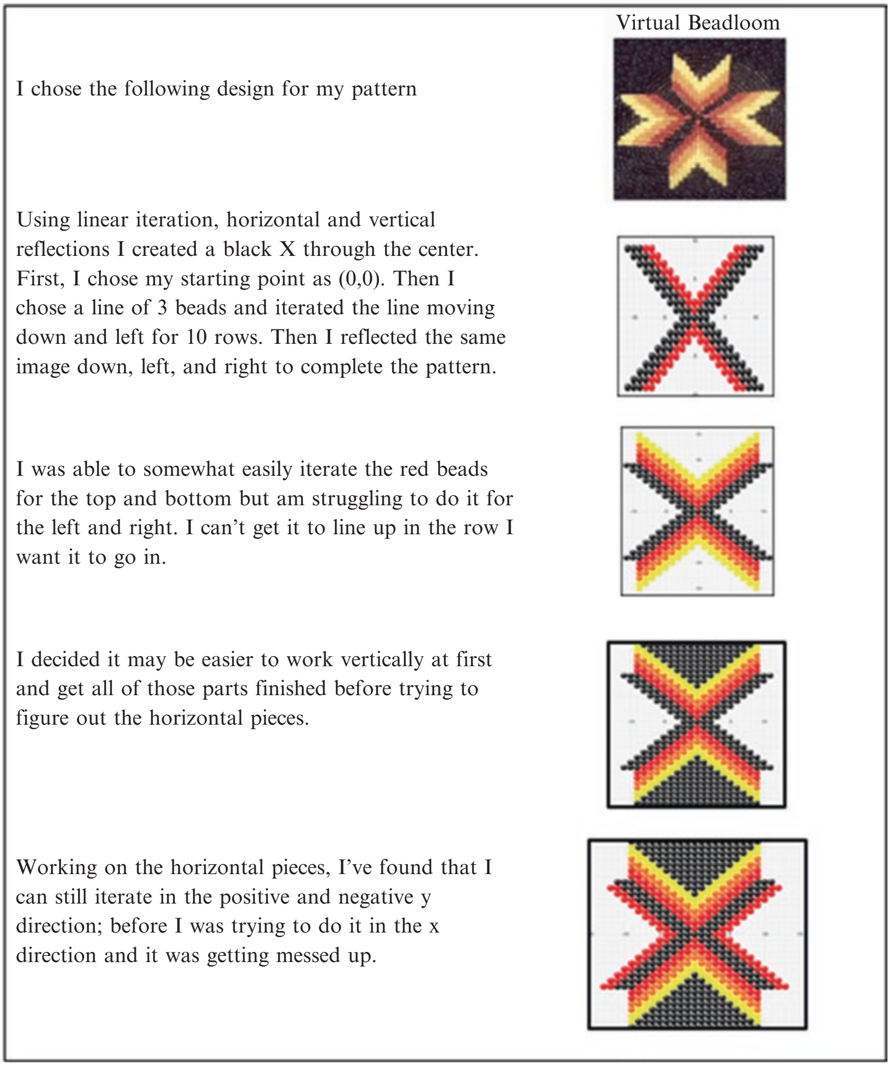


Fig. 18.1 Technology-based construction of a bead loom

- In order to replicate the image I started by creating two large red triangles that were reflections of one another.
- For example, when I decided to make the vertices (0,0), (-20,20), and (-20,-20), I realized that the (0,0) coordinate remained the same; but since the reflection occurred over the Y-axis the X-coordinate would both now need to become positive thus creating the other two vertices as (20,20) and (20, -20) while the y-coordinate remained the same.
- I repeated this process starting with the red triangle and then a white triangle and then reflected it over the Y-axis. Then I created a blue triangle and a green triangle and reflected them over the Y axis as well.
- Once that portion of the beadloom was created I had to perform reflections over the X-axis. I started with the orange/brown triangles and used (0,0), (-12, 20) and (12, 20). To perform a reflection, my new coordinates have to be (0,0) (-12, -20) and (12, -20). In this situation, the X-coordinates remained the same and the Y-coordinates changed. I repeated this process again to create the smaller yellow triangle.

Fig. 18.2 Technology-based creation of a bead loom

Activity 2: Teaching Geometry Using a Sociocultural Art Form

All PSTs completed a course project requiring them to identify and investigate a personally meaningful practice, highlighting the fact that mathematics is a human activity. Each participant developed a mathematical activity and engaged in both content and pedagogical explorations. PSTs explored in depth the mathematical ideas inherent in the activity, and they drew upon their mathematical understandings, designed a mathematics lesson, and completed a field experience with a group of middle school students. Here is an example drawn from one PST's (Sandy) course project (CPA, FE). We chose this project to specifically highlight Sandy's transformation and growth through her participation in this course. At the beginning of the semester, when asked to describe her cultural background, Sandy noted, "I am just from here... so I don't think that I have culture like you do... So I don't know how to find a meaningful cultural/everyday activity" (WR). Upon further elaboration, we came to realize that Sandy associated the term "culture" with the other, a person from a different race, ethnicity, or nationality. Gradually, through her participation in the course activities and continued discussions with her peers, she came to realize that every individual possesses a unique cultural background informed by their lived experiences.

Sandy developed a mathematical activity based on her "family art," cross-stitching. Her late grandmother had taught her the art, and Sandy dedicated this project to her. Sandy used this cultural art form to enhance her own understanding of cross-stitching and graphing on a Cartesian plane using GeoGebra. Her project report included two cross-stitched designs (University A logo and a five-pointed star) and a geometry task based on GeoGebra that she eagerly and proudly shared with her peers. During her field experience (FE), Sandy also shared her designs and the activity with a group of middle school students. It is through these artifacts that the middle school students were able to perceive connections between the art of cross-stitching and mathematics. The students created colorful and intricate patterns on a Cartesian grid and uncovered many connections between their newly created art forms and geometry. Below (Fig. 18.3) is a snapshot of Sandy's description of the mathematics of cross-stitching.

Here (Fig. 18.4) is Sandy's (re)creation of a five-pointed star on GeoGebra. She presented the art form to her peers and engaged in geometrical investigations on coordinate geometry, congruence, similarity, transformations, area, and perimeter.

During our class discussion, many PSTs lamented about the paucity of curricular resources that could be used to teach mathematics using a sociocultural lens. Exposure to and engagement in the ethnomathematics of the Chokwe tribes, South Indian women, nonacademic professionals, and Warlpiri tribe (Ascher, 2002) mitigated part of this concern and enabled PSTs to appreciate the contributions of socially marginalized groups to the evolution of mathematical ideas. From an analysis of PST reflections, we noticed that many PSTs saw a firsthand situation where multicultural contexts became alive in a mathematical classroom and wanted to find additional resources that may be available and were excited to incorporate such activities in their own classroom. As one PST summarized,

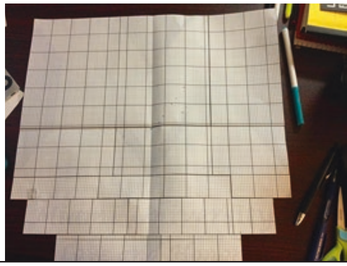
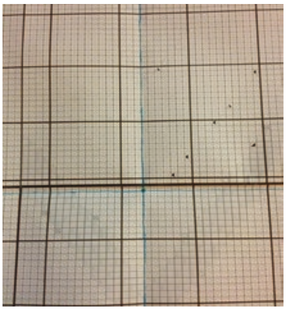
When you are cross-stitching, you are basically plotting points on a quadrant plane. But instead of having the origin marked out for you and the x and y axis labeled and visible, you have to find it yourself and know where it falls within the pattern and on your fabric (as seen in the picture below).	
When starting a new pattern, you always want to start in the middle (origin) and either start off stitching above the middle line (x-axis into quadrants I and II) or work your way below the middle line (x-axis into quadrants III and IV). As you can see in the picture, the origin is not always defined and will have to found by the students themselves, along with the axis. Every box in the pattern is the same thing as being a coordinate point on the quadrant plane. You have to know how many spaces to the left of right of the y-axis to find the x-value and then how many spaces above or below the x-axis to find the y-value.	

Fig. 18.3 Sandy's description of the mathematics of cross-stitching

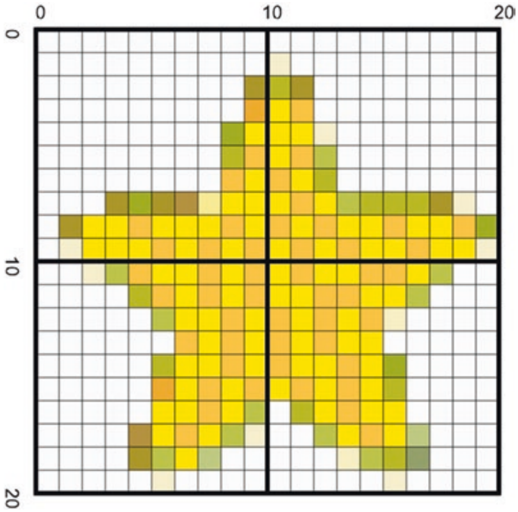


Fig. 18.4 Technology-based creation of a five-pointed star

> I have Native American heritage myself and this type of activity makes me think of my own lineage and the legacy left to me by my ancestors – Moreover, I feel greatly empowered in knowing that I can use this legacy to teaching mathematics and modeling hand in hand.

Many PSTs noted that they gained a greater appreciation for and better understanding of the role of other cultures "within the study of [school] mathematics" (Zaslavsky, 2002, p. 66). Furthermore, they were able to engage in a "two-way dialogue in which [the different forms of] knowledge (community knowledge, school knowledge) and their associated values are brought into the open for scrutiny" (Civil, 2002, p. 146). In the next section, we present a narrative of a course that provided PSTs in University B, an immersive ethnomathematics experience in a non-Western developing nation.

University B: Early Field Experience in a Non-Western Country

Currently, teaching in the USA remains a homogeneous profession; the majority of teachers and PSTs are of European-American descent; PSTs tend to be cross-culturally inexperienced, live within 100 miles of where they were born, and desire to teach in schools similar to those they attended, with fewer than 10% hoping to teach in either an urban or multicultural setting (Cushner & Mahon, 2009). Heyl and McCarthy (2003) suggest that experiences in international education have the potential to be the most influential factor in developing cultural awareness in PST education. They contend, "A key role for higher education institutions must be to graduate future K-12 teachers who think globally, have international experience, demonstrate foreign language competence, and are able to incorporate a global dimension into their teaching" (2003, p. 3). In order to gain a more global perspective, an early field experience was developed at University B to address the PSTs' inexperience relative to a CRME.

Setting and Background

At this institution, mathematics majors seeking teaching certification are able to fulfill their senior capstone requirement through a month-long field experience in Arusha, Tanzania (the fieldwork is completed in 1 month, while the coursework is completed over 8 months, 2 months prior to travel, and 6 months post travel). These PSTs are a representative subset of the students enrolled as mathematics education majors at the university. That is, the PSTs are typically White, middle class, juniors, and seniors [3rd and 4th year university students] who have completed their mathematics content course requirements. They begin their student teaching within a year after returning from Tanzania.

Prior to departure, students attended six orientation meetings in which they read and discussed articles about Tanzanian culture, history, and education and learned basic Kiswahili in preparation for the program. A Kenyan faculty member also attended many of the orientation sessions to respond to questions from the PSTs and assist in the Kiswahili instruction. During their month-long experience in Tanzania, the PSTs taught mathematics in elementary and secondary English medium schools for 60–75 hours. (English is the language of instruction, even though English is not the native language in Tanzania.) The PSTs were responsible for developing the lessons, teaching the lessons, and designing assessments, often without textbooks, materials, or resources. The teaching day concluded with each PST individually conferencing with the university faculty members, followed by a whole group reflection. During this individual conference, PSTs analyzed and reflected on the mathematics lessons they taught and what struggles that both they and their students encountered. It should be noted that the university faculty assisted the PSTs with mathematical content and classroom management recommendations when needed but did not offer suggestions pertaining to negotiating teaching mathematics; the PSTs navigated these issues on their own or with one another. Data were generated and collected from these conferences and teaching episodes. Field notes and audio recordings taken by faculty of these discussions (CPA), observations of classroom visits (CPA), and written documentation of instructional decisions and reflections (WWR) provided a rich source of data to capture PSTs' evolving attention to the principles of CRME. The PSTs responded to reflection prompts posed by the faculty at the conclusion of each teaching day. Prompts included questions such as "What did you do today in your teaching that you hadn't planned to do?", "What surprised you today in terms of your teaching and your students", "What was something you learned today that you didn't know before", "What did you notice is the same in your classroom here (in Tanzania) as classrooms in the U.S", and "Why do you think... ". Next, we provide examples of how this experience addressed some of the key tenets of a CRME.

Using Kangas to Teach Parallel and Perpendicular Lines

Over the course of the month-long experience, the PSTs had numerous opportunities to infuse African culture and mathematical context. At the onset of this experience, however, the PSTs, in an attempt to contextualize the mathematics they were teaching, provided contexts which were unfamiliar or irrelevant to the Tanzanian students. For example, one PST taught a lesson about parallel and perpendicular lines. She provided the context of roads "that run parallel to one another" and roads "that are perpendicular to each other." It was evident to the PST that the students were confused by her explanation, and she attempted to provide another context that did not provide clarification for her students. When she debriefed with her peers at the conclusion of the day, she came to realization that her attempt to contextualize the mathematics was a meaningless (and Western) context. That is, most streets in Arusha do not run parallel or perpendicular; rather, roads were built based on availability of long stretches of land. In order to make the concepts of parallel and perpendicular lines meaningful to her students, she decided that it would be necessary to provide a context that was familiar and relevant to her students. She accomplished this by situating parallel and perpendicular lines with kanga fabric. (Kangas are brightly colored, rectangular fabrics, often with geometric patterns that African women wear as dresses, skirts, and headpieces.) Using a familiar context to the students, they were easily able to see the meaning she was trying to convey of parallel and perpendicular lines. The PST then realized the power of situating her instruction within a culturally relevant context. In this way, the PST connected school mathematics to the sociocultural-ethnical aspects of her students' Tanzanian culture.

Teaching Fractions with Ugali

For another PST, teaching fractions became a struggle as she attempted to demonstrate equivalent fractions. While the context she provided was a familiar one to her students (measuring ingredients to make ugali, a local dish), the vocabulary she used was problematic. That is, terms such as *renaming*, *numerator*, *denominator*, and *equivalent* that she did not know the Kiswahili equivalence for were difficult for her to explain to her students. In order to acknowledge and celebrate the students' cultural background and facilitate understanding, she decided it would be important to infuse Kiswahili terms when appropriate. For students who struggle with understanding the language of instruction, *code-switching* is an important instructional strategy teachers use to assist understanding the meaning of the concepts conveyed. In this way, the PST also practiced equitable pedagogical practices, as she realized the language barrier was impeding some of the students' abilities to understand what was being taught.

Hisabati Katika Kazi (Mathematics at Work)

During the lesson planning session one evening, many of the PSTs decided to create a lesson based on the mathematics adults used at work and home. Unbeknownst to the PSTs, they were attempting to connect the academic mathematics to other forms of mathematics. They were surprised by this connection and remarked that they didn't realize they were even attempting to infuse culture into mathematics. In this lesson, the PSTs asked their students to interview an adult to gather information about the mathematics they use at work. The PSTs' motivation for this assignment was to help their students see the value of mathematics outside of the classroom. The PSTs were not explicitly considering the principles of a CRME; rather, this was merely an assignment they created, "as an activity to do, that we think they will enjoy and help them think about math in another context." When debriefing their lessons, the PSTs began to understand and realize the significance of providing opportunities for their students to connect academic mathematics to other forms of mathematics, a central tenet of a CRME. When the students shared their interview responses (e.g., "My mother is a seamstress and she said she uses a lot of math in her work; measuring fabric, figuring out how much to charge, and what her costs are for making a dress," "My brother drives a cab. He needs to know how much to make people pay for a route so he doesn't short himself"), the children were intrigued and amazed at how important mathematics is outside of the school setting. For the PSTs, they came to the realization that "this was a very powerful lesson, and we didn't even know it!"

Return of the Kangas: Transformations and Kangas

Using kangas also proved a useful tool to teach transformations. The PSTs came to understand the importance of situating the mathematics in a meaningful context, as evidenced in their reflections (WWRs) and our analysis of class discussions (CPA, CRJ), and decided to deviate from the textbooks and create lessons that utilized kangas. Below is an example of the introduction to the lesson the students created about translations (Fig. 18.5). The PSTs took photographs of kangas from a local market which highlighted the aspects of transformations they were teaching. By recognizing the significance of the kanga in the Tanzanian culture, the PSTs were able to make valuable connections to the students while celebrating an important part of their culture.

Mathematics in the Street

The PSTs also had opportunities to interact with various Tanzanians outside of the school setting and gain a broader perspective and appreciation of the importance of a non-Western view of mathematics. For example, they came in daily contact with the local touts (street peddlers), who attempted to persuade them to purchase their wares. Most of the local touts do not have a formal education past primary school.

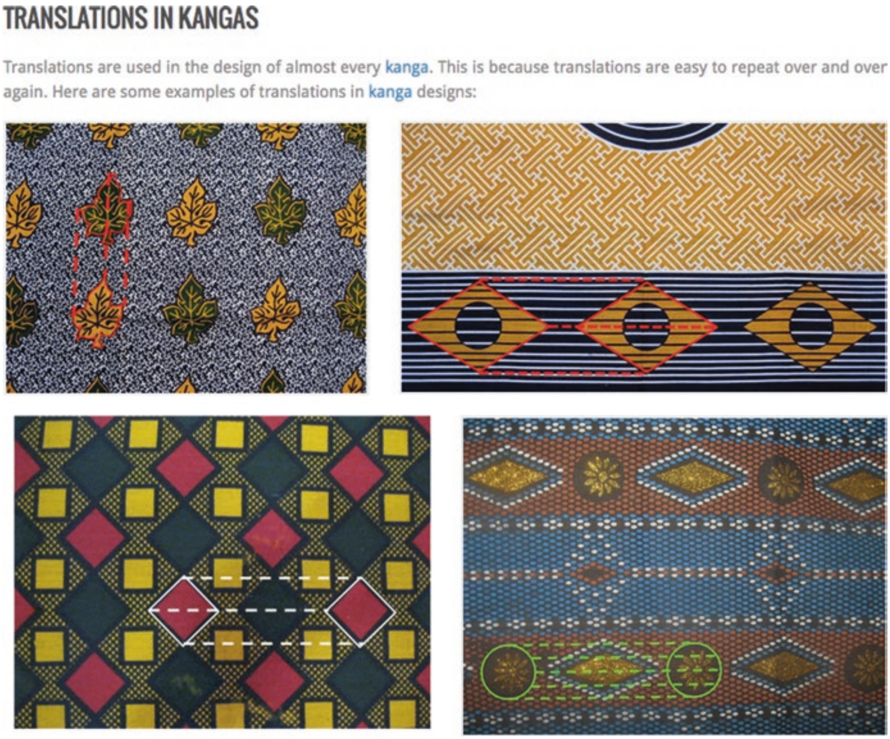


Fig. 18.5 Geometric transformations in kangas

Their ability to make transactions in their heads, however, both amazed and impressed the PSTs. Many of the PSTs remarked that the touts often performed complicated problems related to ratio and proportion with ease. They were also surprised at how they calculated costs and change without a calculator or paper and pencil. One PST remarked, "I am in awe of how easily the touts do mathematics in their head, they are better at this than I am with a major in mathematics." During a whole group discussion, the PSTs came to the conclusion that "maybe we should think about math differently, it doesn't always have to be the way we think of math." This opportunity enabled PSTs to conceive, with the help of local citizens, an alternative view of doing mathematics and acknowledge the way these individuals come to know and understand mathematics.

Reflections: Continuing the Self-Study

As proponents of ethnomathematics, we believe that the central purpose of mathematics education is "to contribute to the development of our collective world, in the direction of more justice" (Mukhopadhyay et al., 2009, p. 75). For quite some time now, we have realized that "the record [dominant perspective] is wrong, and [realized] how that wrong record is culturally disrespectful" (Mukhopadhyay et al., 2009, p. 74) and thus we are better positioned to understand the need and the potential for engaging PSTs in mathematical activities that offer a counter narrative to the dominant perspective.

Thus, in both courses, it was a key priority for us to support PSTs in broadening their perspectives of mathematics and its pedagogy so that they can better attend to the needs of all of their students. The narratives we presented above, and the embedded examples, illustrate ways in which we provided opportunities for PSTs to think deeply about the constructs of ethnomathematics and a CRME. We provided many opportunities for PSTs to acknowledge that much of the so-called Western mathematics "originated in the ad hoc practices and solutions to problems developed by small groups in particular societies" (Katz, 2003, p. 557) and that traditionally told histories of mathematics have neglected the contributions from the non-European cultures and have presented a *Eurocentric view* of mathematics (Joseph, 2000).

In both courses, we introduced PSTs to the social constructions of mathematics through course readings that highlighted the contributions of people who were not necessarily from the mainstream academia. For too long, academic mathematics has presented our students with only European, so-called "refined," version of mathematics, only taught to regurgitate whatever processed form to which we have limited academic mathematics. We wanted PSTs to think deeply about community knowledge and draw upon funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) that existed in rich cultural settings. Thus, we encouraged them to look for connections to mathematics in their own cultural backgrounds and the immediate social backgrounds. PSTs learned about, and engaged with, the mathematics inherent in the sociocultural activities of groups that they barely knew.

It is our hope that, in light of their exposure to the mathematical activities outlined in the two courses, this group of PSTs will be willing to look for and acknowledge other forms of mathematics that exist outside the realms of the academia. We have presented one example through Sandy's project. In her final course reflection journal, she noted: "I see that I have been oblivious to [their] expertise. Upon reflection, I see that I have been oblivious to [their] expertise because I truly did not believe that [they] can be authentic sources of knowledge." We believe that Sandy and many PSTs who took these courses have begun to notice how individuals from many walks of life can become co-constructors of mathematical knowledge. In their final course reflections, many PSTs remarked that they will continue to be mindful of the different connections and ideas that students might bring into the classroom and the importance of connecting mathematics to a culturally relevant context. As a result, we hope that these PSTs will begin to embrace the meaning of learning as "a truthful collaboration in which all parties come both as learners and as resource" (Civil, 1998, p. 7).

In retrospect, we acknowledge that striving to develop and implement a mathematics content course on CRME or ethnomathematics is no easy task. Often times there are neither context, nor content, for such a course in a traditional teacher education program, and at times some resistance from students occurs (Naresh & Poling, 2015). Nevertheless, we believe that if we failed to produce meaningful dialogue, or if it is absent, change cannot occur, and we cannot provide a transformative learning experience for our students. In order to prepare culturally responsive mathematics teachers, it is necessary to "[deconstruct] the aura of incontestability and status that now surrounds mathematics, and certain notions about what constitutes quality instruction" (Gay, 2000, p. 194).

During class discussions and field experiences our PSTs examined questions such as: What is mathematics? If and how is informal mathematics different from formal mathematics? How are mathematical ideas exemplified in the activities of just plain folks? What is the role and purpose of mathematics in their everyday lives? From a dominant Eurocentric view, which forms of mathematics are acknowledged and valued? Why might this be the case? What can we do about this? Many of the course activities were geared toward helping them think deeper about plausible responses to such questions. We hope that, in their quest for deeper answers to these questions, PSTs will further broaden their perceptions of mathematics and its teaching.

Our self-study is specifically focused on explicating ways in which we can use the principles of ethnomathematics to question, understand, and reevaluate the meaning of mathematics and its pedagogy. MTEs' efforts to address practice-oriented problems "may rarely result in tidy answers... when viewed through the lens of self-study" (Berry, 2009, p. 1312). However, this lens enabled us to explicitly model key components of CRME to our PSTs.

Moving forward, we will continue to engage in this self-study and find ways to purposely infuse the principles of ethnomathematics and a CRME into all of the mathematics education courses we teach. In future, we hope to develop a framework to share with our mathematics education colleagues, so they can understand the importance and impact of threading culturally responsive mathematics teaching into all of the courses they teach. As a community of learners, we have come to realize that it is important to "empower students, through broadening, not narrowing their knowledge of mathematics; through inspiring their participation and creativity in contributing to the development of mathematical knowledge, and, for teachers, through the creation of a culturally responsive mathematics teaching" (Mukhopadhyay et al., 2009, p. 72).

References

Arizona Group: Guilfoyle, K., Hamilton, M. L., Pinnegar, S., & Pacier, P. (1998). Negotiating balance between reforming teacher education and forming self as teacher educator. In A. Cole, J. Knowles, & R. Elijah (Eds.), *The heart of the matter: Teacher educators and teacher education reform* (pp. 153–168). San Francisco: Gaddo Gap Press.

Ascher, M. (2002). *Mathematics elsewhere: An exploration of ideas across cultures*. Princeton, NJ: Princeton University Press.

Barton, B. (1996). Making sense of ethnomathematics: Ethnomathematics is making sense. *Educational Studies in Mathematics, 31*(1–2), 201–233.

Berry, A. (2009). Self-study in teaching about teaching. In J. John Loughranm, M. L. Hamilton, V. K. LaBoskey, & T. Russell (Eds.), *International handbook of self-study of teaching and teacher education practices* (pp. 1295–1332). New York: Springer.

Brenner, M. E., & Moschkovich, J. N. (Eds.). (2002). *Everyday and academic mathematics in the classroom*, *Journal for research in mathematics education monograph* (Vol. 11). Reston, VA: National Council of Teachers of Mathematics.

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1987). Written and oral mathematics. *Journal for Research in Mathematics Education, 18*(2), 83–97.

Civil, M. (1998). Mathematical communication through small group discussions. In M. Bartolini-Bussi, A. Sierpinska, & H. Steinbrig (Eds.), *Language and communication in the mathematics classroom* (pp. 207–222). Reston, VA: NCTM.

Civil, M. (2002). Culture and mathematics: A community approach. *Journal of Intercultural Studies, 23*(2), 133–148.

Connelly, F. M., & Clandinin, D. J. (2006). Narrative inquiry. In J. L. Green, G. Camilli, & P. Elmore (Eds.), *Handbook of complementary methods in education research* (3rd ed., pp. 477–487). Mahwah: Lawrence Erlbaum.

Creswell, W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: Sage.

Cushner, K., & Mahon, J. (2009). Intercultural competence in teacher education. In D. K. Deardorff (Ed.), *The Sage handbook of intercultural competences*. Los Angeles: Sage.

D'Ambrosio, U. (1985). Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics, 5*(1), 44–48.

Eglash, R. (2002). Computation, complexity and coding in native American knowledge systems. In J. E. Hankes & G. R. Fast (Eds.), *Changing the faces of mathematics: Perspectives on Indigenous people of North America* (pp. 251–262). Reston, VA: National Council of Teachers of Mathematics.

Fasheh, M. (2000). *The trouble with knowledge*. Paper presented at a global dialogue on "Building Learning Societies – Knowledge Information and Human Development", Hanover, Germany. Retrieved from http://www.swaraj.org/shikshantar/resources_fasheh.html

Fasheh, M. (2012). The role of mathematics in the destruction of communities, and what we can do to reverse this process, including using mathematics. In O. Skovsmose & B. Greer (Eds.), *Opening the cage: Critique and politics of mathematics education* (pp. 93–105). Rotterdam, The Netherlands: Sense Publishers.

García, S. B., & Guerra, P. L. (2004). Deconstructing deficit thinking. *Education & Urban Society, 36*(2), 150–168.

Gay, G. (2000). *Culturally responsive teaching. Theory, research, and practice*. New York: Teachers College Press.

Gerdes, P. (1997). On culture, geometrical thinking and mathematics education. In A. B. Powell & M. Frankenstein (Eds.), *Ethnomathematics: Challenging eurocentrism in mathematics* (pp. 223–248). Albany, NY: State University of New York.

Gerdes, P. (2010). Exploration of technologies, emerging from African cultural practices, in mathematics (teacher) education. *ZDM, 42*(1), 11–17.

Gutiérrez, R. (2008). A "gap gazing" fetish in mathematics education? Problematizing research on the achievement gap. *Journal for Research in Mathematics Education, 39*(4), 357–364.

Heyl, J., & McCarthy, J. (2003). *International education and teacher preparation in the U.S.* Paper presented at the conference on global challenges and U.S. higher education: National needs and policy implications. Duke University, Durham, NC.

Joseph, G. G. (1987). Foundations of eurocentrism in mathematics. *Race and Class, 28*(3), 13–28.

Joseph, G. G. (2000). *Crest of the peacock: Non-European roots of mathematics*. Princeton, NJ: Princeton University Press.

Katz, V. (2003). Book review. *Notices of the American Mathematics Society, 50*(5). Retrieved October 2, 2006, from http://www.ams.org/notices/200305/rev-katz.pdf

Kitchen, J. (2009). Passages: Improving teacher education through narrative self-study. In D. L. Tidwell, M. Heston, & L. Fitzgerald (Eds.), *Methods for self-study of practice* (pp. 35–52). Dordrecht, The Netherlands: Springer.

Lave, J. (1988). *Cognition in practice: Mind, mathematics and culture in everyday life*. New York: Cambridge University Press.

Lumpkin, B. (1997). *Geometry activities from many cultures*. Portland, ME: Walch Education.

Millroy, W. L. (1992). An ethnographic study of the mathematical ideas of a group of carpenters. In *Journal for Research in Mathematics Education Monograph* (Vol. 5). Reston, VA: National Council of Teachers of Mathematics.

Moll, L., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. *Theory into Practice, 31*(2), 132–141.

Mukhopadhyay, S., Powell, A. B., & Frankenstein, M. (2009). An Ethnomathematical perspective on culturally responsive mathematics education. In B. Greer & S. Mukhopadhyay (Eds.), *Culturally responsive mathematics education* (pp. 65–84). Mahwah, NJ: Roultledge.

Naresh, N., & Poling, L. (2015). Statistical education: A context for critical pedagogy. In S. Mukhopadhyay & B. Greer (Eds.), *Proceedings of the 8th international conference of mathematics, education, and society* (Vol. 3, pp. 820–833), Ooligan Press, Portland State University, Oregon, US.

Powell, A., & Frankenstein, M. (Eds.). (1997). *Ethnomathematics: Challenging eurocentrism in mathematics education* (pp. 331–371). Albany, NY: SUNY.

Presmeg, N. C. (1998). Ethnomathematics in teacher education. *Journal of Mathematics Teacher Education, 1*(3), 317–339.

Siromoney, G. (1978). South Indian kolam patterns. *Kalakshetra Quarterly, 1*(1), 9–14.

Selin, H. (2000). *Mathematics across cultures: The history of non-Western mathematics*. Dordrecht: Kluwer Academic Publishers.

Vithal, R., & Skovsmose, O. (1997). The end of innocence: A critique of "ethnomathematics". *Educational Studies in Mathematics, 34*, 134–157.

Zaslavsky, C. (1998). Ethnomathematics and multicultural mathematics education. *Teaching Children Mathematics., 4*(9), 502–503.

Zaslavsky, C. (2002). Exploring world cultures in math class. *Educational Leadership, 60*(2), 66–69.