



# INTRODUCTION

## The Crossroads of Mathematics and Culture

Imagine that you are a young African American student just getting to a class in arts or social studies. In today's lesson you might get to learn about African culture, sculpt with clay, or watch a video on the Underground Railroad. Now imagine you are that same student heading to math class. Will today's lesson on how to find the least common multiple and the greatest common factor hold your interest just as much?

We all know the criticism: Students should be as interested in math as they are in their other school subjects, so if they are not, the fault lies with them. But what if that thinking is wrong? What if there are other ways to teach mathematics to students—ways that turn it into a bridge to their own heritage culture? A ticket to far-off, fascinating places? Or a new medium for sculpting fantastic shapes and for expressing personal and social ideas?

Traditionally, mathematics has been considered a subject one studied in school to learn and practice procedures using numbers and symbols written as algorithms. Mathematics is too often presented as a set of static, unchanging rules developed by ancient people with no connection to current problem solving. In this book, we wish to challenge and expand this perception by suggesting that a far greater number of “mathematicians” use and apply mathematical principles every day.

Some researchers suggest that many students, and in particular many minority students, believe that mathematics has been developed and is owned by a community they are not a part of (Barta, Cuch, and Exton 2012). Gaps in achievement scores have been tied to this disconnect between students in certain communities and how they view and experience what they consider to be another group's mathematics. Rather than focusing on gaps in achievement, we suggest a part of the problem is related to gaps in opportunities for all students to learn mathematics in ways they see as relevant to their identities and communities. While few like to admit it, some teachers, parents, and students still hold to the pervasive misconception that mathematical potential is somehow related to one's genetic background! This belief has no merit, of course, yet what has changed in the way we teach mathematics that will allow a greater inclusion and connection to an increasingly diverse student cultural population? Across the globe, people who would never be considered mathematicians are engaged with mathematical activities in the work they complete, the artifacts they construct, or the objects they design. Mathematics is best understood as we experience its application within the cultures and contexts in which it is applied. Everyone in the world is similar in that we all have a spoken language through which we communicate thoughts and ideas. Within this similarity, however, are

unique differences shaped and defined by culture and communicated through the diverse vocabulary, syntax, and semantics of each language. Mathematics too is a language comprised of many dialects—dialects that denote diverse communities using mathematics.

## A Brief History of Using Culture in Mathematics Instruction

Over time, different approaches and degrees of including culture(s) in the mathematics classroom have prevailed. Here, we will briefly summarize three historic stages of using culture in mathematics teaching as we have experienced them. The stages are *traditional*, *multicultural*, and *culturally responsive*. It is important for mathematics educators to know of these stages and to consider their implications on teaching and learning.

Several decades ago, the Roman numeral system was one of the few examples of culture included in mathematics instruction. The use of culture in this period can be described as “traditional,” because teachers made few, if any, cultural connections as they taught the Roman numeral system. Numbers were merely written as part of exercises to be practiced, often without any story or contextual meaning. Story problems provided a very generalized context describing Eurocentric situations and expectations. Students learned that culture was not a part of mathematics, and even when mathematics was contextualized in a story or situation, that context represented the majority culture.

Authors writing textbooks eventually began to add a multicultural element to the instruction, as they occasionally included examples of diverse cultures demonstrating mathematical concepts and procedures. Certainly this multicultural stage was a step forward from the Roman numeral days, but all too often these inclusions were historical examples, which seldom included living representatives. Mathematics, even when considered from a cultural perspective, was too often presented as something that was practiced in the past by people no longer living.

We will share several historical examples of cultural mathematics in this book, but a far greater portion of our work involves the integration of culturally responsive mathematics instruction. We define culturally responsive mathematics—this third stage in the use of culture within mathematics teaching—as the way that mathematics influences a culture and, conversely, the way that culture shapes the mathematical application being used. The reciprocal interaction of mathematics and culture demands a powerful revision of those previous instructional periods of the traditional and multicultural. Rather than vaguely connected or historical in emphasis, culturally responsive mathematics instruction is contemporary and active.

The available opportunities for connecting mathematics and cultures are as varied as the people living on our planet. When teachers educate from such a perspective, they help their students to see that mathematics is far more than an isolated subject. The study instead becomes a way to understand the role mathematics plays in shaping culture and the ways that culture guides and responds to the use of mathematics in the lives of those

who use it. Such inclusivity allows all students the opportunity to celebrate the mathematical heritage of their people(s) as they gain deeper insights into mathematical concepts and principles.

## Our Central Themes

Teachers are usually excited to find new activities they can use with their students, and students certainly enjoy instructional variety and like to be meaningfully and actively engaged. We believe our global examples of engagement with mathematics will fulfill the needs of both teachers and students. To ensure that teachers who use the materials in this book comprehend key aspects of this instruction, we have provided them with a new way of approaching mathematics with their students within an ethnomathematical lens. *Ethnomathematics* can be defined as the study of the relationships between mathematics and cultures (D'Ambrosio 2001).

By incorporating this study, teachers and students alike can experience mathematics in new and novel ways. Teachers who understand the key components of these materials will better realize the beauty of this integration and its complexity. They can then help their students develop a new relationship to mathematics. Rather than study mathematics from the viewpoint of a spectator, students can participate in mathematical processes that become even more relevant and intriguing when curricular boundaries between mathematics, its applications, and cultures become blurred or nonexistent.

This book emphasizes three specific themes: (1) *authentic application*, (2) *life in numbers*, and (3) *intentional intelligence and use*. Of these three, authentic application may be the most self-evident. As the term implies, it is the active use of mathematics within a situation or context to solve a problem. Alan Bishop, noted ethnomathematician, has suggested that people across the world and throughout time have used mathematics to count, measure, design, locate, explain, and play (Bishop 1988). These six universal actions can be used to investigate the math in what people do, how they live, what they build, and where they live. These universals make apparent the mathematics of an activity, object, or action as the reciprocal interaction of mathematics and the culture. Mathematics becomes best understood by how it is used. Similar activities are practiced by many diverse cultures, and so we are witness to a countless variety of possible solutions to a problem. Divergent thinking, along with a growing understanding of how we can do the same things differently and still succeed, provides a palatable example to expand notions of respect, tolerance, and cultural understanding. As teachers better understand the benefits of employing an ethnomathematical perspective in their teaching, issues surrounding social justice can be explored. Mathematics that is taught from a traditional perspective excludes many cultures that shared in the worldwide discovery and application of mathematics. As mathematics and culture come to be seen as integral components of one another, issues of equity can be examined and greater inclusivity can result.

The concept of *life in numbers* describes a relationship between the action, personality, and animation of numbers with the people using them in a given situation. The traditional

view of mathematics as a study with no cultural component divorced the student from the idea that one could interact with the numbers and develop a relationship with them. An example may help to best illustrate this idea. Elmer Ghostkeeper, a mathematics consultant from Alberta, Canada, was asked why he thought a number of First Nations/American Indian students struggled with mathematics. Elmer, who is himself Métis (First Nation), stated, “Some of our children struggle with mathematics because the numbers do not dance!” (Barta, Jetté, and Wiseman 2003).

Similar to a dance, there exist a number of unique steps peculiar to specific cultures and responsive to the instruments and music that accompany them. As students develop their own relationships and understanding with mathematics resulting from relevant, deep, and personal interactions, they learn to dance with the numbers. When viewed in such a light, numbers do tell stories and models convey meanings. Mathematizing, or the act of mathematical thinking or doing, results from the interaction between the mathematician and the object or activity with which they participate.

*Intentional intelligence and use* is our last theme, and it serves to debunk the oft-presented notion that people in society who employ informal applications of mathematics (that is, out-of-school applications of mathematical principles and concepts) are seldom aware of what they are doing or why they use a particular concept or strategy. We instead explain such intentionality as the purposeful application of mathematical intelligence to challenge an issue or solve a problem. Such informal applications show the conscious use of one’s intelligence to seek a solution, complete a real-life task, or solve a problem in the community. Intentionality requires that teachers become more sophisticated in the examples they use when illustrating culture in the mathematics classroom. Occasionally a “tourist approach” has been used in mathematics classrooms. As children study some far-away country, word problems describe the food, object, or clothes of the day—i.e., *Jaime has three sombreros and Louisa has two more. How many sombreros do they have together at the fiesta?* It is not impossible for a sombrero or a fiesta to provide numerous connections to study mathematics while illustrating a culture. However, when used as in the above example, the object or activity presented adds little to our understanding of either mathematics or the culture. We could have selected virtually any two objects in our attempt to teach children the concept. Intentionality provides us with a better understanding of how the person using the mathematics was thinking of it, and we begin to develop a more accurate understanding of the cultural traditions, values, and meanings inherent in the object or activity.

## The Journey Ahead

This book encompasses eleven world cultures and applications of mathematics presented through classroom activities. We provide an activity specific to each culture for the grade bands of kindergarten–grade 3, grades 4–8, and grades 9–12. Each chapter is framed around an artifact, game, or activity, with an emphasis on the rich cultural knowledge of its use and meaning within its culture, as well as a focus on the intentional use of

the mathematics or concepts embedded in its production or deployment. Our hands-on, inquiry-based activities also often include technology-infused, web-based learning designed to provide a variety of instructional applications for a broad range of students.

The first chapter, **Cornrow Hair Braiding**, considers an intersection of mathematics and culture found in communities in Africa, Jamaica, and the United States. Using web-based software, students will learn skills involving counting, collecting and organizing data, patterns, multiplication, Cartesian coordinates, geometric transformations and sequence, and iteration as they create their own cornrow designs and investigate and apply the mathematics they are learning.

The Ixil, a Mayan culture in the Guatemalan Highlands, provides the next example of mathematics from around the world in the chapter **Math of the Maya**. Farmers in the highland village of Santa Avelina depend on their ability to grow enough corn to sustain themselves and their families. They traditionally have used application-based mathematical calculations to determine planting needs and harvesting results. In the program described in this chapter, the local students of this village are learning how to use contemporary mathematical knowledge to examine planting alternatives, thus leading to lower operating costs and greater productivity for their community. Following in their footsteps, teachers and students using this chapter can solve similar problems using measurement concepts, algebra, and probability, all situated in a rich cultural context.

Exploring mathematics with students in a Brazilian community sets the context for chapter 3, **The Streets of Ouro Preto**. Brazil's forward-looking National Educational System emphasizes interdisciplinary studies incorporating ethnomathematics. Students learn integrated concepts such as calculus, physics, and biology, and they are formally assessed on their abilities to apply them in real-life situations and communicate their findings. As described here, a group of Brazilian students are investigating mathematics along the street through the architecture, history, music, and day-to-day activities of the 300-year-old city of Ouro Preto. Guided by this chapter, their fellow students in other countries can use these investigations as a starting point for learning to better see the mathematics of their own communities and the ways in which mathematics literally helps shape their world.

Chapter 4, **Navajo Beading and Weaving Patterns**, focuses on the mathematics that arises when members of the native cultures of the American Southwest create beadwork and rug weavings. Measurement, geometry, symmetry, and the use of patterns are just a few of the mathematical connections made. The activities in this chapter enable students to learn mathematical concepts involving Euclidian geometry specific to the Cartesian grid as they apply contemporary instruction to design beadwork and rug weavings with the aid of computer software programs.

The African country of Ghana and the rich cultural artwork of the Asante people provide the context for the activities of chapter 5, **Adinkra Symbols**. These symbols are stamped across cloth by skilled artisans, and they convey traditional ideals and beliefs that connect to local proverbs. Students will explore concepts in geometry, measurement, and data

analysis as they examine the many ways mathematics is used by the Asante to create art and communicate and maintain their culture.

Chapter 6, **The Game of Klappenspiel**, looks at a mathematical activity often played in German schools. Students will be challenged to develop successful problem-solving strategies as they explore simple facts, operations, and probabilities. Klappenspiel (“Shut the Box”) provides a fun-filled application of probability calculations. Games of chance are popular around the world, and this is just one example of how mathematics and culture combine to influence the activities of a community.

In chapter 7, **Graffiti Shapes and Styles**, students will take a closer look at a major element of global urban culture. We have used our cultural simulations with students in many places across the United States, and graffiti has been of great interest to students wherever we go. This is not surprising, as graffiti is an artistic practice that crosses all race, class, and gender barriers. Studying it allows us to show how culture can be truly global, through examples of graffiti everywhere from Iran to Costa Rica. Focusing on legal forms of graffiti, such as the murals commissioned by the city of Philadelphia, helps to promote positive social values as well as highlight geometric traditions invented by and for the youth themselves. Making a connection between graffiti and mathematics provides a strong learning motivation for many students, particularly those in urban and inner-city settings. The mathematical connections made here include Cartesian mapping, geometry (including perimeter and area, angles, and measurement) as well as polar coordinates, linear spirals, and logarithmic spirals made using our web-based applet.

Chapter 8, **Stick Charts and Woven Fronds**, explores the mathematics of cultures from Hawaii and other islands of the South Pacific, as displayed in methods of ocean navigation that employ woven palm fronds from plants indigenous to the region. Islanders wove numerous household items, including mats, hats, and even sails for their outriggers. This ancient craft, once so prevalent, has seen a renaissance as people from these communities race to recover what was nearly a lost art. Weaving provides an active way for students to create models they can use to study measurement, patterns, and geometry. The variety of items constructed in this craft illustrates the way cultures use local materials to produce items of daily use, and this application exemplifies how culture, mathematics, and applied technology can intersect to solve everyday challenges. The revival of this once nearly dead art form itself proves the value that people place on maintaining cultural tradition and identity.

In chapter 9, **Rangolee and Kolam Folk Art Designs**, students will explore numerous mathematical concepts and properties inherent in making these creations. In India, making Rangolee and Kolam art is part of the daily activities of women from nearly all socioeconomic groups. These designs are easy to learn and easy to reproduce, and some have cultural significance and stories attached to them. The designs are based on isometric, radial, and rectangular dot matrices, and they reflect a number of mathematical concepts, including ones involving fractions, geometry, and algebra.

The art from Bulgaria depicted in chapter 10, **Embroidery Patterns**, is still practiced today, and well-made pieces draw the interest of buyers and collectors worldwide. Students will learn how geometry as art helps this unique culture maintain a cultural identity. An analysis of the Koch curve allows students in the younger grades to study sequence and patterns, and students in higher grades will be introduced to fractal geometry situated within this cultural context. Other mathematical concepts incorporated here include algebraic thinking and modeling, measurement, ratios, and proportional relationships.

In our final chapter, **Two-Sided Dice of the Potawatomi**, the game of *Kwezage'win* (“dice game”) is explored. Kwezage'win is a traditional game still played by American Indian Nations in the northern United States, and it typifies the way that people around the world have used mathematics to invent and play games of chance. American Indian cultures often used “stick dice,” peach pits, beaver teeth, bird bones, or two-sided disks crafted from locally gathered materials to construct objects for their games. In this chapter, students will explore probability and data analysis concepts as they connect a traditional Native American game with contemporary mathematics concepts.

As we begin our journey in the chapters that follow, we hope the reader now has a better understanding of how mathematics and culture can be intertwined in the classroom and the benefits that can result. We challenge teachers to look for our central themes—*authentic application*, *life in numbers*, and *intentional intelligence and use*—as they and their students participate in the activities. We believe that through such a study teachers will gain a much deeper understanding and appreciation for educating from an ethno-mathematical perspective.