Foundations in Ethnomathematics for Prospective Elementary Teachers

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Abstract
Ethnomathematics is a term that has been coined to elucidate that everyone uses and can learn mathematics. This manuscript demonstrates how a college Mathematics Methods Course at a Doctoral Intensive University in the Rocky Mountain Region can implement the idea of using the culturally diverse background of students as a foundation to teach children learning second languages and children of diverse cultures. This includes one year of quantitative and qualitative research about prospective elementary teachers who were instructed on how to teach children learning second languages during their Mathematics Methods Course. These prospective teachers then applied these methods while completing their student teaching.

Introduction

Ethnomathematics is a "broader view of how mathematics relates to the real world" (D'Ambrosio, 2002, p. 1). Ethnomathematics in the elementary classroom is where the teacher and the students value cultures, and cultures are linked to curriculum. Ethnomathematics "represents a complex and multifaceted dynamic, which illustrates the culturally influenced uses of mathematics through its applications" (Barta & Shockey, 2006, p. 79). Teachers must emphasize the importance of building upon the students' foundational knowledge in a way that brings in their culture and their history in order to promote value in these cultures. This Mathematics Methods Course takes the first step towards ethnomathematics where the qualities of culture are explored to open up this previously unknown topic to prospective teachers. Staats (2006) explains that "ethnomathematics at the undergraduate level must be transformative, not

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only for how students understand their abilities in mathematics but also in how they understand their relationship to others in the world" (p. 41). These prospective teachers must learn how to enhance and restore cultural dignity to the children in their classrooms (D'Ambrosio, 2002).

This research study was two-semesters in length with ninety-two prospective elementary teachers participating. These prospective teachers were taught explicit strategies for working with children learning second languages in their Mathematics Methods Course through the specific course activities and projects of the Enhancing English Language Learning in Elementary Classrooms (Center for Applied Linguistics, 2003) often referred to as the "Farsi Video,", human graph, and lesson plans. The readings from Darder (1991); Echevarria, Vogt, and Short (2004); and Howard (2004) provided context for theoretical knowledge about the importance of focusing on children learning second languages in the elementary classroom. The theme of ethnomathematics philosophical underpinnings is grounded in having respect and some knowledge of how a students' native culture impacts the understanding of mathematics (Reyhner & Davison, 1992), understanding other cultures through *Material World: A Global Family Portrait* (Mendel, 1994), creating mathematics homework based on children's culture and surroundings is one way to bring in the success and family life of the child's community (Zimmerman, 2006), understanding the Yupik Eskimo's of Alaska including the elders, parents, and children in this community and their tribal use of mathematics (Lipka, Wildfeuer, Wahlberg, George, & Ezran, 2001), and the Northern Ute culture of using mathematics as you live (Barta & Shockey, 2006). The results from the study were two-fold. First, quantitative results on a pre-assessment and post-assessment measuring the prospective teacher's comfort level of teaching children learning second languages and diverse cultures were measured. Secondly, qualitative results from the prospective teacher's student teaching assignment demonstrated themes in

meeting the needs of children learning second languages and diverse cultures in the elementary classroom.

Participant Information

The majority of the prospective elementary teachers who participated in this study were female (90%), twenty-five to thirty-five years of age (48%), and of white ethnicity (94.2%) as documented in Table 1.

Table 1
Prospective Teacher Demographics

Gender		Age		Ethnicity	
Female	90%	Under 25 years	15%	White	94.2%
Male	10%	25-35 years	48%	Hispanic	3.8%
		36 and over years	37%	Asian	1.0%
				Other	1.0%

These prospective teachers will be teaching in national public schools where "nearly 40 percent of children are minorities, but just 11 percent of the teachers are" (Kochuk, 2005, p. 17). As represented by the prospective teacher demographics above, one can see that even fewer of these participants (about 6%) are minorities. It is important to bring this foundational knowledge of ethnomathematics to these prospective elementary teachers so that they will obtain the knowledge required to effectively teach children learning second languages and of diverse cultures. This knowledge of ethnomathematics is at the beginning level where these prospective elementary teachers have to have their worldview opened to understand there are ways of learning mathematics beyond their white, female perspective. These prospective elementary teachers need to self-introspect so they can understand the importance of ethnomathematics in the classroom.

Mathematics Methods Course

The Elementary Education Program where this research takes place graduates about 175 students per school year with their Elementary Education Teaching License for grades kindergarten through sixth. The mission of this Elementary Education Program is to help prospective teachers become professionals who are able to perform proficiently in elementary school classrooms situated in increasingly complex, diverse, and technologically advanced communities. The four themes of reflection, modeling, collaboration, and integration flow as the philosophical underpinnings of this program. Both the National Council of Accreditation of Teacher Education (NCATE) and the Association for Childhood Education (ACEI) accredit this Elementary Education Program.

The Interdisciplinary Studies Liberal Arts Major had been designed to prepare students to become elementary teachers. This foundational coursework comes from the core courses of (a) mathematics (b) science, (c) history and social studies (d) language and literature. The courses taught from the mathematics department examine ways of thinking within and across broadly related disciplines. Concentration areas are provided to students for more in-depth study of academic disciplines while allowing them to be sufficiently well rounded to teach all subject areas at the elementary level. There are three required mathematics courses (nine credit hours) taken before beginning the Mathematics Methods Course (three credit hours). This Mathematics Methods Course is an intensive 45 contact hour course that prospective teachers take in five weeks after the prospective teachers have completed their nine credit hours of mathematics for their Interdisciplinary Studies Liberal Arts Major. These prospective teachers are then placed at a school to complete their student teaching assignment for the eleven weeks left in the semester.

Prospective Teachers' Learning

There are many ways to prepare prospective elementary teachers to educate children who are learning second languages and diverse cultures within the realm of ethnomathematics. The most effective way to teach children utilizes the National Council of Teachers of Mathematics' (NCTM) *Principles and Standards for School Mathematics* (2000). Specifically, the prospective teachers in my course learned how to educate children through the content standards of Number Sense, Geometry, Measurement, and Data Analysis and Probability through the Process Standards of Problem Solving, Reasoning and Proof, Communication, Connections, and Representation.

Problem solving is taught and modeled to provide meaningful problems, solving strategies, and opportunities for students to design their own problems, as well as to provide cooperative learning opportunities, encourage multiple ways of solving problems, and encourage the use of visuals in drawings, models, props, or acting out the problem. Reasoning and Proof is taught and modeled to use both examples and non-examples, provide graphic organizers, encourage students to use multiple representations, and provide Venn Diagrams. Communication is taught and modeled to build community and rapport with students, provide vocabulary in context to develop meaning, allow teachers to seek an understanding of what students are trying to communicate, provide visual scaffolding, provide visual opportunities to review vocabulary with clear labels and word walls, identify specific objectives in lesson planning, increase peer interactions to provide language acquisition opportunities, and provide modeling. Connections are taught and modeled to start with prior knowledge, move the concept from concrete to abstract, relate to the real world, relate to the culture and history of the student, provide graphic and advanced organizers, and integrate to connect to other content areas building

on knowledge already acquired. Representation is taught and modeled by using graphs to vary from concrete to more abstract, have students demonstrate reasoning with manipulatives, act the problem out, provide graphic organizers for student recording, and show how to classify objects based on cultural knowledge.

To prepare prospective teachers to teach mathematics to all students, including children learning second languages, best teaching practices are modeled to my prospective teachers. Just as I expect the teacher candidates to use the above strategies, so must I while teaching this Mathematics Methods Course. First, I have to access my prospective teachers' prior knowledge, culture, and histories to get to know them. This allows instruction to be differentiated, meaningful to each individual, and taught at the appropriate level of maturity. Second, I build a safe community where all are ready to learn and share through the Responsive Classroom approach (Charney et al. 1997, 1999). This safe community allows students to take risks in mathematics in a way that challenges the prospective teachers cognitively and places them in cognitive dissonance allowing misconceptions to be challenged. Third, I model how to plan a lesson that considers teaching children who are learning second languages and diverse cultures. This lesson thinking is done out loud for modeling the concept to the prospective teachers. The lesson is then taught to the group allowing them to see how a plan progresses from the planning stages to action in the classroom. Fourth, I demonstrate through the Process Standards of teaching mathematical content with active learning rather than lecturing (NCTM, 2000). This encompasses giving the prospective teachers time to understand the mathematical content through constructivist learning (Crotty, 1998).

Specific Course Activities and Projects

These prospective elementary teachers participated in many course activities and projects to develop their understanding of children learning second languages and of diverse cultures in addition to learning about the national standards (NCTM, 2000) and our state standards. The prospective teachers were asked to think about the following considerations when teaching to children learning second languages and diverse cultures in this case of Latino students: "(1) honor the diversity of Latino students' experiences, (2) know the students and their experiences, (3) avoid deficit models, and (4) provide opportunities for mathematical discussions" (Moschkovich, 1999, p. 9). The instructional elements of the Farsi video, human graph, and a specific session in the lesson plans for children learning second languages and of diverse cultures were the most meaningful activities taught in the Mathematics Methods Course to these prospective teachers based on their Course Evaluation Survey.

Farsi Video

My Mathematics Education Course uses the *Enhancing English Language learning in Elementary Classrooms: Video* as an introduction to children who are learning second languages and of diverse cultures. The first lesson in this video presents a three minute and twenty second health lesson taught in the Farsi Language. The first health lesson is lectured to the audience with a quick rate and pace of speech. When this section of the video is watched in my course, the prospective elementary teachers are given the task of determining what Colorado Model Content Standards are being met as well as evaluating the teaching style of the presenter. These students are then given five minutes to discuss their findings in small groups (five to six students). The groups then report their discussions back to the rest of the class. The class responses generally encompass a wide range of content areas being guessed for the video lesson

from mathematics (as this content covered in the course) to social studies, as well as science and language arts. The actual health content has never yet been chosen as the content being taught in the video from the lectured teaching presentation.

The students then watch the next part of the video wherein the same health lesson is taught to the audience in Farsi, but includes props, gestures, emphasis on key content vocabulary, and a slower rate and pace of speech. The students participating in this experience can now understand that the lesson is a health lesson being taught as well as comprehend the actual components of the lesson. Students then go back to their groups and are able to complete the task of determining what Colorado Model Content Standards are used.

The following questions are posed to the small groups of prospective teachers. Group answers are then reported back to the whole class. The typical class responses follow the question below.

1. How many of you knew Farsi when we started the video? The answer is that no one yet speaks the Farsi language.
2. How did you understand the health lesson being taught the second time if you do not speak the Farsi language? The answer here is that the teacher is doing more than just talking as she is engaging students into the lesson being taught. The moment is taken here to teach the prospective teachers that instruction can be made comprehensible for children who are learning second languages and of diverse cultures through building on the student's prior knowledge (culturally and historically); moving from concrete to abstract; focusing on making meaning of new vocabulary comprehensible; incorporating the use of pictures, props, demonstrations and hands-on activities to show meaning; talking about the content being shown; and simplifying the speech (Franco, 2003).

3. What can you do to succeed in teaching all students in your future elementary classroom regardless of if they speak English or not? This answer focuses on the observable teaching strategies used in the video including props, gestures, emphasis on key content vocabulary, and a slower rate and pace of speech. The answer also includes strategies for mathematic content such as (1) application or expansion when mathematics vocabulary is introduced based on their cultural experiences, opportunities for student interaction with the vocabulary, and a concrete example of the concept is created, expanded, or included into correct schema, (2) discussing vocabulary by using it in context to progress concept(s) from concrete to abstract (3) exploring questions and pictures from their community to help define vocabulary and (4) differentiating instruction to meet all learning needs (Franco, 2003).

It becomes clear to the prospective elementary teachers in my course how much easier it is to understand the lesson through these teaching techniques even though they do not speak the language in the video. This fifteen-minute experience makes a vivid, lasting impression on those who participate to help create an understanding of the challenges of learning through a language barrier; furthermore, it demonstrates teaching strategies and practices that help overcome that language barrier and models good teaching for all learners regardless of their culture.

Human Graph

The human graph deals with how the prospective elementary teachers perceive empathy towards children who are learning second languages and other cultures. The human graph is a physical number graph on one wall in the room. This left side of this wall represents the quantity of zero, the middle of this wall represents the quantity of five, and the farthest right hand side of this wall represents the quantity of ten with all the numbers in between zero through five and six

through ten being represented. The students then physically go stand next to the number on the wall that represents the quantity they wish to express. If there is more than one student who chooses the same quantity than the students stand one in front of another creating a visual human graph for comparison and discussion.

The definition of empathy is discussed with the whole class giving the foundational knowledge for the human graph activity. The Oxford American College Dictionary (2002) defines empathy as the ability to understand and share the feelings of another (Lindberg). Students are then given the task to physically move to the section on the human graph that represents the quantity they believe to be true based on the one-to-ten scale for the following questions:

1. During your first student teaching experience, what empathy do you believe your host teacher had toward children learning second languages? Why?
2. During your first student teaching experience, what empathy do you believe your host teacher had toward children with diverse cultures? Why?
3. During your first student teaching experience, what empathy do you believe your elementary school had toward children learning second languages? Why?
4. During your first student teaching experience, what empathy do you believe your elementary school had toward children with diverse cultures? Why?
5. What do you think the empathy level is for children learning second languages in the city of Greeley? Why?
6. What do you think the empathy level is for children with diverse cultures in the city of Greeley? Why?

7. What do you think the empathy level is for children learning second languages in the state of Colorado? Why?
8. What do you think the empathy level is for children with diverse cultures in the state of Colorado? Why?
9. What do you think the empathy level is for children learning second languages across this nation? Why?
10. What do you think the empathy level is for children with diverse cultures across this nation? Why?
11. What is your personal empathy for children learning second languages? Why?
12. What is your personal empathy for children with diverse cultures? Why?

The "why' portion of each question is discussed while the group of prospective teachers are part of the human graph. This human graph activity helps prospective elementary teachers look at the issue of children learning second languages and children with diverse cultures in the classroom in contexts ranging from social to personal based on their observations and experiences at the community, school, state, and national levels. This activity also engages students to think outside of their own culture and empathize with cultures that are different from their own based on the population of these prospective elementary teachers who are female (90%), twenty-five to thirty-five years of age (48%), and of white ethnicity (94.2%).

Lesson Plans

A section specifically addressing children who are learning second languages and of diverse cultures has been added to the lesson plan requirement in my Mathematics Methods Course. This helps prospective elementary teachers consider students of varying backgrounds who will be in their classroom while continuing to practice teaching methods and strategies that will help

each student learn. This requirement has been added to multiple assignments including the Mathematics Concept Lesson Plan, Integrated Mini Unit Lesson Plan, and the Thematic Unit Lesson Plan. The first two individual student lessons are taught to classroom peers in order to develop mathematical concepts and enhance the integration of language arts, social studies, and other content areas with the mathematics subject matter. The final Thematic Unit of lessons (five hours worth of teaching) is taught to elementary children while the prospective teachers are completing their student teaching. This unit is developed, planned for, taught, and evaluated by the prospective elementary teacher and integrates many content areas. This section, which specifically addresses children learning second languages and children with diverse cultures, has been added to all three assignments encouraging prospective teachers to consider these questions: (1) how will you ensure all students will learn from this activity or lesson? and (2) how can you access your student's prior and cultural knowledge? This practice of thinking about all children will greatly enhance the instruction provided in the elementary classroom for children of varied backgrounds and experiences.

Quantitative Mathematics Course Results

A colleague, Carol Picard, and I examined the effect of children who are learning second languages through the prospective elementary teachers in our Mathematics Methods Courses. In Fall semester of 2003 and Spring semester 2004, a pre-assessment on the first day of the course and a post-assessment on the last day of the five-week course were conducted to examine how comfortable our prospective teachers were in teaching children learning second languages. Ninety-two prospective teachers participated in both assessments. The instrument used to measure their comfort level with children learning second languages had a Cronbach's alpha reliability of 0.96 for the Likert-type instrument of 24 questions. The factor analysis completed

was a Varimax rotation with the Principle Components Method. The factor analysis through the Scree Plot and Component Matrix confirm that we are measuring one trait: confidence in teaching children learning second languages and of diverse cultures at the elementary level.

Out of the 24 questions on the survey, there were 13 that were significantly statistic ($p<0.001$) showing the growth of the prospective elementary teachers in the area of preparing instruction and teaching children learning second languages and of diverse cultures. The specific areas of growth include creating grouping configurations that will support language and content objectives (67.4% increase), providing hands-on material and/or manipulatives for students to practice using new content knowledge (91.3% increase), clearly supporting language objectives through lesson delivery (82.6% increase), understanding how to emphasize and apply key vocabulary (78.2% increase), and understanding how to use a variety of techniques to scaffold content concepts for students who are learning second languages (e.g. modeling, visuals, hands-on activities, demonstrations, gestures, body language, and culture) (71.7% increase). The Mathematics Methods Course demonstrates the confirmed comfort level the prospective teachers felt about teaching children learning second languages when they left the course (Picard & Harding-DeKam, 2004).

Qualitative Research Results

The thematic unit assignment for prospective elementary teachers is a holistic look at the teaching and learning cycle in the classroom requiring prospective teachers to plan for at least five hours of instruction that is an integration of mathematics, social studies, and language arts or an integration of mathematics, science, and language arts. The thematic unit is then taught to elementary students where the prospective teachers are conducting their student teaching. After the unit has been taught, the prospective teacher reflects upon what learning took place for their

students in both quantitative and qualitative evaluations, evaluates the level to which the Thematic Unit helped prepare students to meet the state standards, discusses changes they would make the next time they taught this unit, and demonstrates how they meet the Performance-Based Standards for Colorado Teachers while teaching this unit. Units on average are about fifty pages in length and show the specific planning, teaching, learning, and reflection that take place while teaching in the elementary classroom.

Table 2
Grade Levels Taught During Student Teaching

Grade Level	Frequency	Percent
Kindergarten	8	8.7%
First Grade	18	19.6%
Second Grade	16	17.4%
Third Grade	15	16.3%
Fourth Grade	11	12.0%
Fifth Grade	19	20.6%
Sixth Grade	5	5.4%

The qualitative diversity research takes place in the natural setting of the elementary classroom through the prospective teachers reflections on how they met the Performance-Based Standards for Colorado Teachers. The grade levels taught represent kindergarten through sixth grade as seen in Table 2. This qualitative inquiry (Schwandt, 2001) is aimed at understanding how prospective teachers applied the course learnings about teaching children learning second languages and diverse cultures through ethnomathematics in the elementary classroom during student teaching. The research methodology implements emergent and systematic ways of finding themes (Creswell, 2003; Merriam, 1998). The three Performance-Based Standards for

Colorado Teachers focused on for this research of children learning second languages are as follows:

1. Standard 5 – Knowledge of Classroom and Instructional Management: The prospective teacher is knowledgeable about classroom practices in order to successfully manage time, communications, and record keeping procedures that will support and enhance student learning.
2. Standard 6 – Knowledge of Individualization of Instruction: The prospective teacher is responsive to the needs and experiences children bring to the classroom, including those based on culture, community, ethnicity, economics, linguistics, and innate learning abilities. The prospective teacher is knowledgeable about learning exceptionalities and conditions that affect the rate and extent of student learning, and is able to adapt instruction for all learners.
3. Standard 9—Knowledge of Diversity: The prospective teacher creates an inclusive learning environment for all students by drawing upon representations from students' experiences, knowledge, and beliefs.

Results

The qualitative data was collected from the Thematic Units and the themes from the data emerged. These themes were taken from the reflective essay section where the prospective elementary teachers demonstrated how they meet the Performance-Based Standards for Colorado Teachers in the areas of diversity and ethnomathematics. These prospective elementary teachers demonstrated how they met Standards 5, 6, and 9 throughout the teaching of their thematic unit and the following major themes emerged from the data:

1. Prospective teachers used the Thematic Unit lesson plans to develop ideas to help meet the needs of children learning second languages and of diverse cultures (98% of the prospective teachers).
2. Prospective teachers successfully applied differentiated instruction to their students in the classroom (64.2% of the prospective teachers).
3. Prospective teachers implemented different teaching techniques to build upon student's prior content knowledge and cultural knowledge (32.4%).
4. Prospective teachers demonstrated the respect for their students' culture when developing lesson plans, teaching the lessons, and assessing the students (23.1% of the prospective teachers).
5. Prospective teachers created a safe learning environment for all students in their classroom (16% of the prospective teachers).
6. Prospective teachers held different students accountable for content in different ways (8.7% of the prospective teachers).
7. Prospective teachers reflected upon how they would use student's cultural and foundational content knowledge if they were to teach this thematic unit again (7.2% of the prospective teachers).

This qualitative data demonstrates how these prospective elementary teachers support children learning second languages and of diverse cultures in the classroom during their student teaching experience through the use of ethnomathematics.

Conclusions

These prospective elementary teachers are building their own foundation of learning when it comes to teaching children learning second languages and diverse cultures. This is a

beginning understanding of how the culture and history of a child play into the elementary classroom in the realm of ethnomathematics. This groundwork of foundational knowledge in ethnomathematics for these prospective teachers was established through the Mathematics Methods Course with the most effective and highest impact activities recorded by the prospective teachers as being the Farsi video, human graph, and adding children learning second languages and diverse cultures into lesson plans. This growth in teaching children learning second languages and of diverse cultures is supported by the quantitative data of the prospective teachers' comfort level and the qualitative data of themes based on the reflection of the prospective teachers.

These experiences allow prospective elementary teachers to see the need to teach all students through ethnomathematics. This need for ethnomathematics must be established in prospective elementary teachers before specifically looking at different ways of teaching mathematics culturally in the classroom to give the awareness of the need to know ethnomathematics and why it is important in the classroom. After these prospective teachers have this philosophical underpinning, then we move into learning the specifics of mathematics from other cultures.

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