SUPPORTING LEARNING FOR NAVAJO STUDENTS THROUGH ETHNOMATHEMATICS

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This report has been approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE in Applied Science Education

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ABSTRACT

Teaching Navajos Math Through Ethnomathematics

By

Tracy L. Hunter

The purpose of this research was to address how culturally informed ethnomathematical methods of teaching can be utilized to support the learning of Navajo students in mathematics.

The study was conducted over the course of four years on the Navajo Reservations at Tohatchi Middle School in Tohatchi New Mexico. The students involved in the study were all in 8th grade and were enrolled either in Algebra 1 or a Response to Intervention, RTI, class. The data collected came in the form of a student survey, student observation and student assessment. The teacher written survey, a math textbook word problem, and two original math textbook problems along with their rewritten version were the sources of these three studies. The first year of the study consisted of a math attitude survey and how Navajo students perceived math as a subject of interest. The students answered four questions pertaining to their thoughts about mathematics. The students’ responses were positive according to their written answers. The second year of the study involved the observation of how students worked through a math word problem as a group. This method tested how the students culturally interacted in order to solve a math problem. Their questions and reasoning to solve the problem were shared with peers and the teacher. The teacher supported the students in understanding and solving the problem by asking questions that kept the students focused on the goal of solving the problem. The students worked collaboratively and openly in order to complete the activity. During the
study, the teacher was more able to notice the students’ deficiencies individually or as a group, therefore was able to support them in a more specific manner. The last study was conducted over a period of two different years. This study was used to determine how textbook bias in the form of its sentence structure or word choice affects the performance of students who are not culturally familiar with one or both. It was found that the students performed better and took less time on the rewritten problem than on the original problem. The data suggests that focusing on the culture, language and education of Navajo students can affect how the students learn and understand math.
Acknowledgments

This project would not have been possible to accomplish if it were not for the guidance, support, and encouragement of Dr. Kedmon Hungwe, my advisor; thank you. I would also like to thank the faculty and staff at Michigan Technological University for their programs and opportunities that supported me throughout this process. And much thanks to my family for their constant inspiration and belief in me. Most of all, I would like to thank my ex-husband, Rob, who started me on this path of education and believed that I could accomplish more if I put my mind to it. His support and patience, as well as reassurance have always been appreciated. And last of all, I would like to thank my daughter, Ashley, though working on this project took my time from her, she never complained; she just praised me and said I could do it.
Chapter 1- Area of Focus

Introduction

The teaching of mathematics in public schools has been a major concern throughout the years in the United States. The problem has been particularly acute among America’s indigenous populations. Teachers who are mostly drawn from the dominant European culture generally lack the knowledge and methods needed to teach students from culturally diverse backgrounds that are different from their own. How does a teacher on the Navajo Reservation teach the students without falling into the repeated rut of deducing that: these students do not want to learn, they are behavior problems, they are lazy, they do not get it, their parents do not care about their education, or the students are so far behind that the teachers inadvertently start to believe that it is useless to teach a population that does not want to learn? In the end, teachers start lowering their classroom standards, teach and re-teach basic elementary skills, blame the students or their parents, or give into “teacher burnout”; the teacher gives up on his or her students before the school year has ended. In conclusion, a continued cycle prevails which leaves the students at a disadvantage for the coming school year and those that may or may not follow.

Research in ethnomathematics may provide teachers with ideas and strategies that support student learning more effectively. A starting point is to recognize and appreciate that the student is not just an empty slate waiting to be taught knowledge. This outmoded view was criticized by Paulo Freire (1998) more than thirty years ago, who called this the ‘banking’ or ‘transmission’ view of teaching and learning. Students are treated as
‘objects’ into which teachers pour prescribed knowledge, resulting in rote learning, and stifling their ability to develop higher order skills such as critical thinking (p.4). What has been called for is the recognition that the student is a whole person who deserves to know that he or she is valued for who he or she represents in the community or in society. Many Navajo students suffer from self-esteem issues, possibly developed during their elementary school years, negatively affecting how the student sees him or herself as a capable and able learner. The lack of confidence becomes more evident to the student in the classroom, when the teacher who is either non-Native or who is Native American but educated by Westernized methods, becomes the classroom “ruler” and the keeper of all knowledge and content. This approach leads the student to believe that he or she will never easily grasp new knowledge, and that he or she will continually lack the ability to progress to higher levels of education.

The teacher unconsciously develops misconceptions about their students as the months or years continue to pass, never realizing that they played a major role in the students’ cultural self-esteem, its development and its synthesis with academics. Centered on the teacher’s personal experiences and views, assumptions and low expectations are placed on the students that are far from what they need to continue learning mathematics. Consequently “what may happen is that the dominant culture of the teacher becomes the only culture valued in the classroom,” and the students struggle to learn within a foreign context (Presmeg, 1998). More research on previous works based on Ethnomathematics may help educators better understand the perspective in which Native Americans are best able to learn.
Culturally Informed Pedagogy

There are many cultural applications that can be taken into consideration when it comes to teaching mathematics or science to Navajo students, as well as other indigenous people. The main principle is to teach important concepts from the subject but grounding them in experiences that students can relate with. As an example, it has been suggested that Geometry could be taught by using home measurements, such as the area or perimeter of the walls, floors, windows, and living area. The Hogan which serves as either the Navajos’ home or religious structure, or sometimes both, has a polygonal shape. The Hogan’s six or eight sided shape has much importance to the Navajo people in reference to its number of sides and the direction in which the door faces. The study of polygons, degrees, or directional mapping could be introduced to the students by utilizing the Hogan as the focal point.

Geographical data from the students’ own home areas could be used to teach concepts in algebra. As an example, the geographical area in which the Navajo Reservation is located contains many points of interest. Popular locations such as Shiprock, Monument Valley, and the four states: Utah, Arizona, Colorado and New Mexico: the “Four Corners”, could be used by students to map out the Cartesian coordinate system. These four states, as well as the students’ familiar towns, like Window Rock, AZ, the Navajo Reservation’s capital, or Shiprock could be plotted on the coordinate system.

The same principles can be applied to the construction of word problems. Many Navajo families do not have running water, therefore, they take their laundry to one of the local towns costing them at least twenty-five dollars to wash and dry the clothes, fuel
the vehicle, and to feed their family per trip. Calculating their cost per year in comparison to purchasing a washing machine, students will be more able to apply their math skills to an applicable situation that affects them and their family. As for understanding rates and calculating weight: students whose families save aluminum cans or collect metal scraps in order to add to their weekly income, will again be utilizing ethnomathematics; integrating their culture into an applicable way to better understand mathematics and its methods of calculations.

In summary, there are many cultural and environmental situations that could be used to apply the students’ mathematical skills when ethnomathematics is used as a basis of Native American teaching. For instance, there are many math texts that are used in public schools around the USA; it is essential that teachers be able to analyze the content of the textbooks, and adapt them where appropriate in order to better support student understanding. Also, knowing and understanding the answer as to why students are “performing well simply for future benefits, grades, college majors, and job opportunities” or to complete school in general will determine the amount of emphasis put on these goals by the teacher in the classroom (Hadfield, Martin, & Wooden, 1990).

Focus Question

The purpose of this research is to address the following question: How can culturally informed ethnomathematical methods of teaching be utilized to support the learning of Navajo students in mathematics?

This research focused on how the Navajo culture, language and education of Navajo students could affect the teaching and learning of mathematics among Native Americans. It explored the practice of ethnomathematics in teaching Navajo students
about solving word problems and understanding their attitude and perspective about math.
Chapter 2 - Literature Review

Introduction

The traditional Western methods used to teach Native Americans often leave a gap between the teacher and learner. Educators may be unaware of the significant elements needing consideration when teaching Navajo students. The students’ families plays a large role in the decision making as it relates to the students’ life choices and short and long term educational goals. Ethnomathematics, defined by Kitchen (2001) “places the mathematics of the local culture at the forefront of instruction” (p. 152), therefore giving the students a perspective that they can relate to when learning math. Using the students’ perspective as a strategy to teach them math allows the teacher to naturally and holistically focus on the student and his or her educational needs. The student’s family, socioeconomic status, language(s), diverse culture, and teacher/student rapport are all taken into consideration when lessons and student/class goals are being developed. By practicing and developing this approach to teaching students, the teacher and his or her students can collectively develop the best methods and strategies focused on the relevant concepts of mathematics.

Theory of Ethnomathematics

The approach to teaching students mathematics should validate as well as emphasize the uniqueness of the students’ culture (Kitchen, 2001). Students should not feel that they are being alienated from their culture. Students should be allowed to learn mathematics in a familiar and useful manner that empowers them to achieve academic success while allowing them to legitimately understand mathematics (Kitchen, 2001). Ethnomathematics is believed to “foster the idea that mathematics is a product of culture
and is affected by cultural forces” (Kitchen, 2001, p. 152). As a result, this method builds upon the students’ experiences, values and culture.

Ubiratan D’Ambrosio (1985) created the term ethnomathematics. It is defined as a “mathematics which is practiced among identifiable cultural groups, such as national-tribal societies, children of a certain age bracket, labor groups, [and] professional classes and so on” (p. 317). The cultural aspect of math can refer to broad historical, traditional, or indigenous cultural practices, or it may mean the mathematical practices of subcultures such as the Brazilian children who sell candy or the Navajo silversmiths who ply their trade to support their families (Kellermeier, 1998). African women may have been the first to create the lunar calendar. They would have been familiar with the lunar cycle and how it correlated to the menstrual cycle, and how the moon’s cycle also affected the cultivation of the land. Ethnomathematics is as an integral part of the development of human civilization (Kellermeier, 1998). The Navajo people too had their own way of surviving off the land, by means of ethnomathematics which they used to think about their environment in order to survive. Today, those skills and practices developed by the Navajo remain in use and can be used by teachers to develop their lessons.

**Cultural Identity**

Historically, young Native Americans “were instructed in manual skills, such as cooking, hunting, making lodges, beading, and making dresses” (Hale, 2002, p. 1). The education was informal and oral. Utilizing living skills similar to these helped the Navajo people survive. Many of these skills are still used today: skills such as, learning and practicing the traditions of the Navajo or Dine religion and culture, gathering or chopping
wood, building corrals, sweat lodges or hogans, erecting fences, a shed, or home, cooking, herding sheep, butchering a goat, sheep, or cow, riding a horse, participating in a rodeo or caring for the participating rodeo livestock, finding an afterschool job to help out with domestic finances, or helping to raise the cattle, horses, sheep, pigs, chickens, and or domestic animals. Cultural stories are used by Native American parents to educate their children before they reach the age of three (Hale, 2002). Navajo children continue their learning by listening to stories or by practicing the skills needed for their family’s survival.

In the past, before Western society migrated to the Southwest; “the missionaries with [their] conversion and the government with [their idea of] assimilation want[ed] to change Native Americans to fit another idea and another mold” (Hale, 2002, p. 18). The missionaries and government set out to save the people from themselves, assuming that indigenous people needed to be civilized and taught the proper way to live. Native Americans were referred to as savages and treated them as such, though the Navajo people had “a culture far in advance of that of any of their neighbors” (Locke, 1992, p. 4). Many educators, today, have not adjusted to the Native culture. Teachers must take into consideration the cultural experience and goals of the Navajo people and figure out how they can best instruct them without denigrating or marginalizing their culture.

**Navajo Language**

Culturally and historically, “storytelling has been traditionally used as a way of education among American Indians and Alaskan Natives” (Hale, 2002, p. 127). Today, storytelling has declined in its usage. A lot of people think of storytelling as just entertainment for kids, but for the Diné it helps maintain tradition and language.” It
would be beneficial for teachers to research Navajo stories that relate to their instruction then integrate them into their lessons.

The Navajo language is still integrated within the family structure which affects many of our students who are English Language Learners and have difficulty understanding the academic language. Though the knowledge and usage of the Navajo language by Navajo students varies depending on their situation, the formal language is still very difficult for these students to comprehend and use. In many cases the version of English spoken at home is a hybrid of both Navajo and English, therefore making the “mathematical word problems requir[ing] students to understand language, culture, the context of the problem, and the mathematics…[more] complex and often confusing for …[such] culturally and linguistically diverse (CLD) students” (Wilburne, Marinak, and Strickland, 2011, p. 461).

According to Hale (2002), classrooms where traditional Western instruction is practiced, the word problems used “are often based on white experience” (p. 126). Modifying word problems to be culturally sensitive to the population will be more beneficial for the learner. Unfortunately, according to Nichols (1992) “students whose language background is non- or substandard English may read and interpret tests incorrectly.” (p. 32). In the end, Native American students remain discouraged, as well as placed more at a disadvantage in comparison to their non-Native American peers.

Davison (1992) reminds us that a “student whose first language is not English is not accustomed to hearing the mathematics vocabulary outside the mathematics classroom” (p. 157), nor does the student fully understand the context and the culture of the story; this in turn, makes it more difficult for a student to read or develop a picture in
their mind in order to solve the given problem. Davison also states that “students who come from homes where the English language is not used extensively are less likely to be aware of the varied meaning of such terms.” Conversations with parents or guardians of CLD students can help support the teacher in planning lessons that integrate the students’ perspective, therefore help to create language connections more appropriately.

**Teacher**

Many Native Americans fail to continue their education during their secondary years, while few make it to post-secondary schools where many drop out. When a teacher thinks that his or her students cannot learn math, the teacher has already failed at teaching the student. There is a big difference between traditional educational strategies used in traditional “curricula, textbooks, techniques, [and] tests” and those reflected in ethnomathematics (Gellert, Jablonka and Keitel, 2001, p. 63). As a result, Navajo students have learned to believe that they are unable to understand something as abstract as Algebra. Gilliland (1992) states that “academic performance is . . . directly related to self-esteem (p. 11). Navajo students’ self-esteem is easily diminished, due to, not only their teachers’ attitude about their abilities, but also due to state test scores that suggest that Native American students are unable to do math in general. According to the Florida Department of Education (2010) “selections about culture- or region-specific topics should not create an advantage or disadvantage for any particular group of students with a particular characteristic, including gender, race, ethnicity, religion, socioeconomic status, disability, or geographic region.” (p. 6).
Studies have shown that many tests are biased and not culturally sensitive to Native Americans, many of whom are English language learners. As for example, math teachers of ELL students “identified cultural bias when problems included unfamiliar or confusing words or phrases such as roller coaster, washers in a jar, drawing a counter . . . and kitchen island.” For some Navajo students, they are not familiar with the word “patio” or “street block”, due to the Navajo Reservation lacking these structures. This makes it difficult for a student to visualize the object, therefore it puts the student at a disadvantage to envision and solve the problem. Champagne (2006) explains that even today, “very little work . . . has been done to integrate Native history and culture into the mainstream curriculum, and the curriculum remains relatively alien to many Native students” (p.150). As school districts adopt new textbooks, they must take into consideration all students who will be affected by the curriculum. Gilliland (1992) recommends that “whenever possible, basic skills should be taught using culturally relevant materials and experiences” (p. 25). Families and community members should have a voice in the selection of the school’s choice of curriculum, due to the impact it will have on their children. “The historical and practical knowledge base of the community served must be valued and must serve as a starting point for the education of the children” (Gilliland, 1992, p. 25).

Many suggestions to teaching Native Americans evolve around ethnomathematics. “Education for Native students need[s] to focus on their own history, culture, and legal and policy issues” (Champagne, 2006, p.148). Teachers need to create lesson plans that are relevant and appropriate for their students and their communities,
“so they can see their own culture, identities, and interests in the school curriculum and their future paths of work and commitment to their communities” (p. 148). All Native students should be given the proper tools to maneuver “Western education and translate it to contribute to community preservation, development, and nation building within tribal contexts” (p. 148).

Without these familiar and culturally relevant ideas, students do not have background information on which to build new concepts. Teachers should pay close attention to the “mores, the values, [and] the learning methods” (Gilliland, 1992, p. 22) of the students they are teaching so they may be applied accordingly in the classroom. Using methods of teaching that are foreign to students will make them “less well adapted to living within their own culture” (p. 22). “If the school uses methods appropriate to the children’s background there is no reason . . . children of any minority group should make less progress educationally than those of the dominant society” (p. 22). Hale (2002) states that when teaching and “using occasions and events that are familiar to the students, teachers are able to approach mathematics in a way that lessens the potential of Native American students developing a fear of the subject area” (p. 127). Many Navajo students already suffer from self-esteem issues which negatively impact their learning, therefore “if their own culture is rejected by the school, they may be forced to reject either their own or the mainstream culture. Whichever they choose, they are handicapped, not only academically but in all of life” (Gilliland, 1992, p. 3). In the end, “it is clear that the successful completion of school by American Indian students . . .
depend[s] on the teacher’s ability to understand the culture” Bearcrane’s study (as cited in Gilliland, 1992).

In conclusion, just like any other culture, Navajo students too should have the opportunity to use their knowledge of mathematics as a foundation for learning school mathematics. The goals of mathematics education should not be lowered for Navajo students. Mathematics should be taught in ways that make it culturally meaningful and accessible to Navajo students. Ethnomathematics gives Native American students the opportunity to share how they understand math and how it applies and will continue to apply to their lives. In the end, this concept of math will allow the students to be successful in their environment, their studies, and their survival toward any life goals they choose to achieve.
Chapter 3 – Method of Study

Setting

This action research study was conducted at Tohatchi Middle School in Tohatchi, New Mexico on the Navajo Reservation. The Navajo Reservation is mostly rural and about the size of West Virginia and spans into three states: New Mexico, Arizona, and Utah. Tohatchi Middle school on average has a population of 198 students, grades 6th – 8th. Tohatchi is in the Gallup McKinley County School District, which covers 13,500 square miles; some students come from as far as 30 miles away every day to attend Tohatchi Middle School. Other students arrive to school by bus which on average is about a 1.3 hour bus ride. The Gallup McKinley County School District serves 36 schools; elementary through high school, and has a school enrollment of about 12,000 students per year on average, about 85% of which are Navajo, the other 15% consist of other Native American tribes, Hispanics, Asian, Caucasian, and African American.

Selected Grade Level

This study took place in two Algebra classes and a Math RTI (what New Mexico calls “Response to Intervention”) class over a period of three years, 2010-2013. All classes are made up of 8th grade students. One study addressed textbook bias; it was given to two different Algebra classes. Another lesson applied was an interview involving five students and a math word problem from the students’ current 8th grade math text. As for the third study, a questionnaire about the students’ attitudes toward mathematics was given to one Algebra class.

Participants
These classes were more accessible for the study because I was the teacher for the Math RTI and Algebra classes which made up the testing groups. The first year I taught Algebra, the students were selected for Algebra by their previous math teacher due to their success in Pre-Algebra. Unfortunately, these students were not ready to learn Algebra objectives, due to their lack of Pre-Algebra skills. During the second and third year, the students were placed in Algebra mostly due to their state test scores, and very little due to their previous teacher’s recommendation of good attendance and positive attitude; overall this was a better enrollment process for the Algebra class in reference to their background knowledge of Pre-Algebra skills. Each Algebra class consists of 108 minutes total per day, five days a week. The Algebra class enrollment from my second to third year of teaching has grown from 8 to 18 students from school years 2010 to 2011. Our goal for the school is to continue to increase the Algebra enrollment each year. The Math RTI classes were selected for comparison purposes and their accessibility. If a student was failing their regular math class or just struggling with mathematics, he or she was placed in this intervention class for extra math support based on the student’s individual needs. Math RTI classes are in session for 54 minutes per day, five days per week. Due to the samples being based mostly on student availability, bias is present. The following studies focused on Ethnomathematics which centers the lessons on the students’ culture, language, environment, and previous experiences (see Table 1).
Table 1  
*Studies of Math Learning in four phases*

<table>
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<tr>
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<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
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<tr>
<td>Year(s) when study conducted:</td>
<td>Fall 2010</td>
<td>Fall 2010</td>
<td>Fall 2011 and 2013</td>
</tr>
<tr>
<td>Duration of study:</td>
<td>One - 54 minute period</td>
<td>One - 54 minute period</td>
<td>One - 54 minute period</td>
</tr>
<tr>
<td>Grade Level:</td>
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<td>8th</td>
<td>8th</td>
</tr>
<tr>
<td>Number of students:</td>
<td>8</td>
<td>5</td>
<td>22</td>
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**Study 1**

**Math Attitude Survey**

The teacher-made questionnaire will assist the teacher in obtaining a better perspective as to how the students will personally and culturally view learning about mathematics. The questionnaire was given to a group of eight 8th grade Navajo students then analyzed for the students’ interests, likes, and dislikes of learning math. Asking students about their interests and overall attitude about mathematics, applies the full concept of Ethnomathematics which places the students at the center of learning and the direction in which the class is aimed. Seven of the 8 students scored proficient and one scored nearing proficient on the New Mexico state math assessment for eighth grade students at the end of the year.

**Study 2**

Objective: The students will use inquiry and peer collaboration to solve a mathematical word problem by applying the distributive property and substitution.
A McDougal Littell math word problem was given to a group of 8th grade Navajo students. The group consisted of 5 students. The students used problem solving skills, shared their inquiry with one another, and communicated with the whole group on how to solve the given word problem. The students continually collaborated with each other and the teacher in order to reach the solution. The results of the study helped the teacher to better understand the students’ needs as they verbally processed and openly shared their ideas to solve the problem. This method enabled the teacher to quickly observe how the students comprehended the problem, devised a plan, and how they implemented the plan.

Materials: McDougal Littell textbook, copy of word problem for students, pencil, calculator, chalkboard, and chalk.

Box 1: Math Word Problem

For a cylindrical corn silo with the dimensions shown, the weight \( W \) (in pounds) of the corn silage inside is typically given by \( W = 4400(40 - d) \), where \( d \) is the distance (in feet) from the top of the corn to the top of the silo.

a. Use the distributive property to write the given formula without parentheses.

b. Calculate. Suppose \( d = 15 \) feet. What is the weight of the corn in the silo?

c. Interpret and Apply. How many days will the amount of corn from part (b) last if is used to feed a herd of 100 cows and each cow eats 10 pounds of corn a day?
Study 3

Objective: To test whether rewriting mathematic problems from the cultural perspective of the students improves their performance. Each original and rewritten form
of the given word problems were conceptually the same in reference to the objective being met.

One group of eight and one group of fourteen 8th grade Navajo students participated in the study. On Study 3A: four of the students were given the original textbook problem. The other four students were given the rewritten culturally relevant math problem. On study 3B: seven of the students were given the original textbook problem. The other seven students were given the rewritten culturally relevant math problem. To ensure that all groups were equivalent, the students were paired with a partner whose math skills, as measured by grades, were similar or the same. The students were timed according to how long it took each of them to complete the assignment. The students all started at the same time.
Box 2: Mathematics problem reconstructed to make it culturally meaningful

Original textbook problem for study 3A

The number of red frogs exceeded the number of blue frogs by 80. The number of green frogs was 20 less than the number of blue frogs. If there were 120 blue frogs, what was the sum of the reds, the blues, and the greens?

Rewritten math problem:

On a ranch there are 120 cows total. But there are also 80 more sheep than cows and 20 fewer horses than cows. How many animals in all?

Box 3: Mathematics problem reconstructed to make it culturally meaningful

Original textbook problem for study 3B

Bucolic themes dominated the exposition, as 70 percent of the paintings were bucolic in nature. If 2000 paintings were exhibited, how many were not bucolic?

Rewritten math problem:

Western themes dominated the exposition, as 70 percent of the paintings were western in nature. If 2000 paintings were exhibited, how many were not western?
Chapter 4 - Results

Introduction

The results are presented in three studies. Study 1 focuses on students’ backgrounds. Study 2 focuses on observations of problem solving activities. The third study compares student assessment results for a textbook problem, and a rewritten equivalent problem adapted to the students’ background

Study 1

Eight students, male and female, participated in the study. The survey consisted of four questions relevant to mathematics. A survey of four questions was given to the students to determine their attitudes and backgrounds. (See Appendix A for the questions)

Question 1: Without using names of teachers, educators or family members, etc.: What person(s) helped you the most in learning and or understanding mathematics and why? Please give details and examples. You can use examples from elementary, middle school, home, summer programs, etc.

Three out of 8 students stated that it was mostly their family members who helped and or taught them about mathematics. While 3 out of 8 students indicated that their teachers were the ones who helped them with their understanding of math. The remaining 2 out of 8 students said that both their family and their teachers encouraged them and helped them understand the subject of mathematics.

The students’ perspective of math was mostly positive as stated by a couple of students who said it’s “fun” and “I love it”. More than half of the students claimed that they had support from their family members. While some claimed that their teacher was
the person who helped them understand math by being encouraging and caring about their future and life plans. Most of the students felt that they understood mathematics fairly well and at an early age. One student writes “my aunt and sister . . . helped me the most when I was younger.” While another student states “My two sisters because they both love math, and I do to.” With the exception of one student, all the students wrote many positive things about learning math. The teacher-made questionnaire was helpful in gathering students’ perspective on mathematics. This feedback is helpful in directing the teacher toward a better understanding of how and why students are individually interested in mathematics. Each student’s perspective becomes more prevalent; therefore, the teacher has a clearer picture of how to better reach the student as he or she progress throughout the school year.

**Question 2**: What type(s) of math lessons do you like, understand, and prefer to learn from? Such as “I like learning from lessons that are short and that use counting beans and markers...” Or, “I like Geometry because shapes are easy for me to understand...” Please give examples that support your answer(s).

Seven of the 8 students preferred math assignments that challenged them. While 3 out of 8 favored work that was easy. Algebra was selected by 5 out of 8 the students as the type of math they wanted to learn more about. One student stated that using manipulatives or technology aided in her learning of mathematics. Multi-step problems were preferred by 6 of the 8 students, while 3 out of 8 students chose to work on single-step problems.

The majority of students preferred to be challenged more as one student states “I like . . . the ones that challenge me to the point where I ask questions to understand more
because it gets my mind working and it pushes me to do well in mathematics.” The students indicated that they would like math problems that were either long or short, had numerous steps, or made them really think about the main concept. As one student writes “I like to do Algebraic things like solving for x or finding the point-slope form method.”

This type of feedback indicates to the teacher that the students are not lazy and that they are willing to be “pushed” to learn. This information should be reflected in the teacher’s expectations, therefore not mistakenly lowered based on the teacher’s misconceptions of the students’ assumed outer attitude. At the other end of the spectrum, 3 of the 8 students stated that they would prefer to do work that they already understood, therefore a challenge was not what they were expecting all the time. This is a small percentage which is indicative of the few students who need motivation and other supports in order to be successful or choose to learn about mathematics. Any questionnaire used to explore students’ ideas and thoughts about math, would be very useful in the guidance, planning and progress of the whole class.

**Question 3:** What ideas do you have that you think would be helpful to you or other students in learning mathematics? Think of the types of strategies such as working in small groups, pairs, working one-on-one with the teacher, or receiving homework to practice skills, etc.

Seven of the 8 students agreed that peer tutoring helps them and their classmates understand new concepts. Five out of 8 students agreed that group work as a method is useful when sharing ideas while learning math. Three of the students stated that one-on-one support from the teacher aides in their understanding of math, while 2 of the students said that teacher/student modeling, quizzes, working at their own pace, or having
examples supports their math education. Half of the students like whole class instruction as a method of learning. Last of all, only one student asked for practice or homework for reinforcement of her understanding of mathematics.

One student wrote: “Group work will probably help us, because some people get stuck and are too afraid to ask the teacher for help” while another shares: “Things that could be helpful in our class would be group work so us students can interact with each other.” Most of the students preferred that their learning be based on group effort: peer tutoring, small groups, one-on-one, modeling, whole class instruction with communication, practice, that they be allowed to take as much needed time to understand the concepts, some homework, quizzes, or working at their own pace. The suggestion for strategies based on students input, directs and determines how the students will learn and whether they will be receptive of the new information being provided. If teachers allow a student directed class, they will have more progress overall for each individual student, due to the students having a voice in their own learning. Culturally, the students are choosing to learn as a whole group, therefore everyone is successful, not just one or a few of the students. Students are willing to help their peers understand the math concepts so they are not singled out by the teacher. A teacher at times calls on the student to answer questions that he or she does not understand, therefore embarrasses him or her. Due to students being friends or relatives, they prefer that their classmates not be singled out or put in an uncomfortable situation. Culturally, the students have made connections in and out of school, therefore the students are more familiar with one another then their teachers realize. The students may live in the same community, be related to each other or have a closer relationship due to growing up together or have parents that are
acquaintances. When teachers understand this cultural concept and allow it to support the teaching and learning, the majority of students will buy into the classroom process and routine. This concept then becomes a team effort, not an individual competition which deems winners and losers in the end.

**Question 4:** *Where would you like to be in the future when it comes to knowing or understanding math and why?*

Five of the 8 students in the class would like to go to college after school and or get a job. Overall, 6 of the 8 students would like to understand as much as they can about math for personal reasons or to help others. One student explained that she would like to be a veterinarian or a chef among other things. With these goals in mind, this student will need to be well versed in math. If a teacher is aware of the overall goal a student, and or his or her family are looking to achieve for them, then the strategies to motivate and ensure progress toward that goal throughout the school year will come easily for both the student and teacher. One student would like to attend “medical school to pursue [her] life long dream of becoming a pediatrician/pediatric surgeon.” Of these 8 students, 5 wanted to attend college, with this said, the most important thing a teacher can do is encourage and support his or her students to keep striving for their future goals. Not only are Native American students perceived as not being interested in attending college after high school, their teachers seldom promote them to attend or prepare them for college. Due to the low percentage of Native Americans currently attending college or completing a post-secondary degree, Native American students need the encouragement, support, and positive feedback which will shape and build the student’s self-esteem in striving to accomplish this goal. Teachers have the power to encourage or discourage a student as it
relates to their academic progress. Students believe that their teachers know everything, therefore take to heart what a teacher says to them, whether it is positive or negative. When a student develops the idea to attend college, by no means should he or she be discouraged; historically, discouragement is what he or she knows well.

Based on this survey, the teacher will have a deeper understanding and perspective on goal setting and supporting the students in the classroom. Both family and teachers play an important role in encouraging and motivating students to learn about mathematics. By asking students about their interests and overall attitude about mathematics, this survey implements ethnomathematics, therefore placing the student at the center of learning. Due to researcher interpretation, availability, and size of sample, bias is present.

**Study 2**

A problem from the textbook was given to a group of five 8th grade Navajo students. The students discussed the problem with the teacher as a whole group. The goal was to better understand the students’ needs as they processed and solved the word problem. The problem is represented below.
Box 4: Math Word Problem

For a cylindrical corn silo with the dimensions shown, the weight $W$ (in pounds) of the corn silage inside is typically given by $W=4400(40-d)$, where $d$ is the distance (in feet) from the top of the corn to the top of the silo.

a. Use the distributive property to write the given formula without parentheses.

b. Calculate. Suppose $d = 15$ feet. What is the weight of the corn in the silo?

c. Interpret and Apply. How many days will the amount of corn from part (b) last if it is used to feed a herd of 100 cows and each cow eats 10 pounds of corn a day?

Figure 1: Cylindrical Corn Silo poorly copied from McDougal Littell textbook onto students’ assignment.

Figure 2: Cylindrical Corn Silo as seen in McDougal Littell textbook.
Results

All the students struggled with the terminology or formulas. Due to many of the students being English Language Learners, they had difficulty with the math terms, such as silage, silo, dimensions, cylindrical, typically, and distributive property. As an example the teacher asked the students at the beginning of the lesson to state what words they did not understand. The students said “Silage, silo, dimensions, cylindrical, and typically”. One student asked “What is the distributive property?” then stated “I don’t get this”. Then when the teacher asked the students to read part “c”, all the students paused and looked at the teacher questioningly. The teacher had to break the question down by asking “How many cows are there” and “What math operation do we use to determine how much corn the cows will eat?”. (See Appendix B)

Four of the 5 students would use guessing to find the next math operation they would use. When the students were asked to use the distributive property, one student asked what it was, while one student wrote down “w x 400 + 4400” and another wrote “(40-4400)”. Three other students did not start, until two of them saw an example of the distributive property on the board, then one of the students wrote down on her paper: “4400 x 4 – d” and the other student wrote “w = 4400 (40 – d)”. The teacher then proceeded to write “w = 4400(40) – 4400d” and explained how the distributive property works. Another example was when the teacher asked the students what math operation they were supposed to use to answer part “c”, one student answered “times” and another answered “divide” the students were supposed to divide on part “c”. When the teacher asked the question: “how many pounds will be needed to feed the cows for one year?”, the students paused and indicating that they did not know how to begin to answer the
question. The teacher then broke the problem into smaller parts in order to help the students select the math operation they would start with. (See Appendix B)

Working as a group, allowed all the students to decipher and think aloud on how to solve the problem. The questions that students asked helped to determine what they were unfamiliar with or stuck on. When the students paused or had puzzled looks on their faces, the teacher was queued to prompt them with a question so they could move on. For example the students did not understand what 110 stood for after they divided two numbers. “The teacher paused for student response. The students were quiet as they waited for the teacher’s next statement.” The teacher then said “110, represents the days.” But the teacher also added the following question: “How many days in a month?” in order to prompt the students to the next step. The students at one point calculated 3.6 months, but stated that there were 3 months which they would use for the next step of the problem. The teacher again interceded and stated to the students, “3?” “What about the point 6?” Then one student said “4, about 4 months”. Using this method of group work in the classroom will assist students with their comprehension and understanding of unfamiliar words. The teacher was able to determine where the students were lacking in direction, therefore would steer them using leading questions which directed them where they needed to go next. (See Appendix B)

The organization or method used to work out the problem varied among each student. The students used each other’s ideas and questions to direct their next step in working through the problem. As an example one student noticed that the distributive property procedure was posted on the wall so she started copying it, in turn another student saw what she did, therefore copied the procedure as well. Though they used the
means of a poster and each other to solve the problem, they still needed more guidance in using the distributive property. Another example of peer support was when a student stated that he knew what the silo was then explained his experience about it: “I know what that is, it’s a can that has corn.” “I’ve seen these on farms – they have corn in them”. This shared information was useful to the other students in the classroom who were not familiar with silos. The teacher asked the students leading questions in order to know how and what the students were thinking in solving the problem. This method of solving problems would be beneficial to the teacher when it comes to planning lessons, projecting student need, understanding where students are at when it comes to their thought processes and language knowledge. This lesson will support the teacher in utilizing specific strategies to assist each student with their individual math weaknesses. (See Appendix B)

Students were more apt to discuss their reasoning, ask questions, and to talk about their thoughts while in a group; this is in comparison to past lessons where students had worked individually. Students were observed being more verbal by making statements such as “I don’t get this”, “What is the distributive property?”, “This does not seem right”, and “That’s a lot of corn!”. (See Appendix B)

Allowing students to think aloud and collaborate with one another can change the environment of the class and how students relate to problem solving. But they must first be given the opportunity to do so. In this time of deeper understanding, inquiry, and common core assessments, students must be able to dig deeper into their understanding of concepts. This method of group collaboration helps students practice their questioning skills, motivates students to really understand what they are being asked, and gives
students the opportunity to see other ideas and problem solving techniques in progress. This collaborative method of learning also supports second language learners in other ways. For example, the students are able to participate and listen to the academic language as its being used, and they are also given the opportunity to ask peers or teachers for immediate support, as well as obtain various peer perspectives on problem solving techniques. Overall, not only will Navajo students be able to participate in a common practice of group collaboration, but those who are second language learners will also be able to build on their comprehension, reading, and language skills as well.

**Study 3**

The following study compared two different school district adopted math textbook problems to a rewritten version of each problem. The rewritten problems use culturally relevant objects, words and or sentence structuring. Twenty-two students, male and female, participated in the study. This study took place in two different Algebra classes at Tohatchi Middle School on the Navajo Reservation. These students were enrolled in the only available Algebra class offered at the school where students can earn high school credit. The study initially took place in 2011 with 8 students then it was repeated in 2013 with 14 students. In each study, pairs of students were matched based on their profile, and assigned to different groups. This pairing, resulted in two groups that were judged to be equivalent for the 2011 year and the 2013 year. The 2011 year groups were assessed on a problem straight from the textbook and its rewritten and restructured version. The 2013 groups were assessed on the original word problem and its rewritten version, only words were changed.
Results

The findings are summarized in Figure 1 and Figure 2 (a score vs. time-on-task graph for 2011 and 2013), and Table 2 and Table 3.

The data from 2011 and 2013 indicate a consistent pattern. Students completing the rewritten problem outperformed those completing the original textbook problem. The students who completed the original problem in 2011, had a mean score of 56.52 and a mean time of 4.75 minutes. As for the students who completed the rewritten and structured problem in 2011 had a mean score of 100 and a mean time of 2.67 minutes. The rewritten problem had a mean score percent increase of 77%, and the mean time percent it took students to complete the rewritten problem dropped by 44%. The students who completed the original problem in 2013 had a mean score of 17.86 and a mean time of 1.286 minutes. As for the students who completed the rewritten problem, they had a mean score of 37.5 with a mean time of 1.033 minutes. The overall mean time percent decrease for the students who completed the rewritten problem in 2013 was 20%, and the mean score percent increase for the rewritten problem was 109%. The scatter plot (Figure 1 and Figure 2) summarizes the score-time-on-task pattern for each set of groups. Figure 1 and Figure 2 indicate that the original word problem, represented by diamonds, show a trend of students taking more time and earning lower scores, as opposed to the rewritten problem in Figure 1 and Figure 2, represented by circles, which indicates a trend of students taking less time and earning higher scores.

One student stated that she did not understand a couple of the words on the original math problem therefore it made it confusing to understand. The students who worked on the original problem were observed looking around the classroom with a
confused expression on their face. It was not until after they completed the activity, when the teacher told the class that they did not all have the same problem; many of the students showed relief and did not look confused anymore. The data suggests that students perform better and take less time completing problems that are culturally relevant compared to problems that have no significance to the students and their culture.

<table>
<thead>
<tr>
<th>Score (Textbook original)</th>
<th>Time taken (min)</th>
<th>Score (Textbook re-written)</th>
<th>Time taken (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched pair 1</td>
<td>100</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>Matched pair 2</td>
<td>75</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Matched pair 3</td>
<td>0</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>Matched pair 4</td>
<td>50</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>Average</td>
<td>56.52</td>
<td>4.75</td>
<td>100</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>42.7</td>
<td>1.71</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 1: Original and Rewritten textbook word problem, 2011
The data suggests that carefully constructed math problems which relate to a student’s cultural background, supports his or her understanding and achievement. Many
of the culturally and linguistically diverse (CLD) students struggle with two languages, Navajo and English. These students are either in the ELL program and are receiving accommodations that meet their bilingual needs, or were in the program and still struggle to comprehend new or academic vocabulary. The results of the 2011 and 2013 textbook studies infer that students failed to fully understand what the original problems were asking, due to the vocabulary, sentence structure, or wording of the question. During the annual ELL assessment for the CDL students, it was found that paraphrasing and re-reading the questions are accommodations the majority of these students need for classroom and state testing. Many of the students understand questions that are read or paraphrased for them, as opposed to them reading the questions on their own. The students received high marks for listening comprehension compared to reading comprehension. Therefore when students read problems that show bias and contain words that can be taken literally, it makes it more difficult for students to envision what the problem is asking them. As a result, it takes the students longer to devise a plan to solve and complete a problem. Words unfamiliar to the students, such as “bucolic” or “exposition”, or objects such as colored frogs, makes a problem less imaginable for students to solve or to fully complete. Ensuring that all math word problems in math textbooks and state assessments are un-biased, will not only avoid advantages or disadvantages for Native Americans, but will also give Native Americans an equal opportunity to compete for academic scholarships which will support them in progressing toward a post-secondary education.
Chapter 5 - Conclusions

Teaching Native American students math has been noted as a difficult undertaking by many teachers in the secondary field of education. One way to address the problem is to use concepts from ethnomathematics. The results from the study indicate that when ethnomathematics is utilized by teachers, they are more likely to improve the learning experiences and outcomes for students. These results are similar to the finding of other cultures, such as where “schools and the mathematics classroom culture play an important role in how [other minority groups, such as] African American students see mathematics” (Moody, 2001, p.274) and how it “influenc[es]… student[] success in mathematics” (p. 274).

Many teachers are not familiar with Native American culture, so they continue to struggle to meet the needs of the students. Students learn better when they are given the opportunity to learn and when their teachers believe in their abilities to learn. If teachers give their students the impression they are unable to learn higher order math skills, the students give up and become inattentive. When this situation occurs, the teacher reverts to re-teaching, believing the students do not understand or are unable to complete the assignment. The teacher then focuses on teaching the students basic skills which then triggers the students to become bored. From this point forward, a stagnant pattern develops and the rest of the year gets longer for both the student and the teacher. The math attitude survey indicated that the students were willing to learn and be challenged. In classrooms where the work is too easy, students get off track, and are observed and noted by their teachers as being lazy. Asking a student about his or her behavior would help the teacher better support student learning.
Another lesson learned during the first study was that students have a positive attitude about learning math. Many teachers believe that Native American students do not like school or learning in general, especially learning about math. Some teachers have chosen to believe that Native American students would rather socialize than learn. Some teachers think that parents do not care, but according to student comments, parents are involved and care about their child’s education. The students in the study reported receiving a lot of attention, tutoring, and support from home. Despite what teachers may think or believe, it would be best for them to talk with the students and parents if they have any concerns about student progress.

Study 2 which involved open discussion shed light on what the students struggled on and needed support with. Teachers will be able to better support their students if they provide some lessons that involve group discussion and collaboration. Many students struggled with the academic language as well as with the comprehension of math terminology. Bilingual students tend to take longer to read and understand problems. The study highlights the importance of teachers taking more time to prepare lessons that support their English language learners. When the students worked together, they were not afraid to ask questions or talk about what was on their mind. This opened up the floor for further inquiry, questions, and feedback from the students.

Though it is impossible to know beforehand what the yearly state test might entail, it would be encouraging to know that the people who write the state test items are familiar with the cultures of populations in which they are writing for. On a recent state test, the students came across the word “coaster” which they did not know, it is not known yet how this affected their performance. In study 3, where textbook bias was
tested, it was determined that when the students took longer to answer the question, they answered the question incorrectly, or they answered quickly and incorrectly. When students have a difficult time understanding what they read, it affects how they interpret the information and how they set up the problem in order to solve it.

**Suggestions for Further Studies**

Working with a group of teachers to find out how their understanding of the values, experiences, and culture of Navajo students possibly affects their students’ learning, would be of interest. The teachers can build lessons that reflect the culture, and compare them to the results of lessons that do not. The teachers can have discussions that pertain to their thoughts and ideas about the culture and weekly experiences. In conjunction, the idea of teachers collaborating to rewrite textbook and classroom assessments which are culturally relevant to the school population would also support student learning. The results from the classrooms where the rewritten problems were used can be compared to the results from the classrooms that used the original problems.

In reference to the academic language and vocabulary, data can be collected from a list of words students are and are not familiar with. This data will be continually collected throughout the year on the same list of words. Selected groups of students will be taught the meaning of those words by the implementation of ethnomathematics. The other groups of students will follow the traditional methods the teacher utilizes. At the end of the year students will be given the list again and a comparison of word acquisition will be assessed.

I plan to work with students and teachers as it relates to helping Non-Native American teachers understand the culture of our students. This will support both the
teachers and students’ future success in and out of the classroom. I plan to continue on this journey of teaching Native American students math, so I can share this knowledge with other teachers coming to the Reservation. I also plan on integrating science and math to support students through more than one field of study.
References


Florida Department of Education


APPENDIX A

Box 5: Math Attitude Survey

Name: _____________________________
Date: ______________________________

Dear Algebra Class,

I would like to know more about why you like or dislike math, why you do well in math, why you are where you are in your understanding of mathematics, and where you would like to be later in life in reference to understanding mathematics. This project will hopefully help me understand from the student’s perspective how you see mathematics in your life.

So, if you would please answer the following questions as completely and entirely from your point of view. I would really appreciate it. ☺ Thank you, Mrs. Hunter

On a separate paper, number each answer to the given question. Staple this paper on top of your answer sheet(s) when you are done.

1. Without using names of teachers, educators or family members, etc.: What person(s) helped you the most in learning and or understanding mathematics and why? Please give details and examples. You can use examples from elementary, middle school, home, summer programs, etc.

2. What type(s) of math lessons do you like, understand, and prefer to learn from? Such as “I like learning from lessons that are short and that use counting beans and markers…” Or, “I like Geometry because shapes are easy for me to understand…” Please give examples that support your answer(s).

3. What Ideas do you have that you think would be helpful to you or other students in learning mathematics? Think of the types of strategies such as: working in small groups, pairs, working one-on-one with the teacher, or receiving homework to practice skills, etc.

Last of all,

4. Where would you like to be in the future when it comes to knowing or understanding math and why?
Teacher: “Read the problem number 45(above), and tell me what words you do not understand or are unfamiliar with?”

Students: “Silage, silo, dimensions, cylindrical, and typically.”

The teacher explains to the students that the photocopy on the left side (below) of the word problem did not photocopy very well. Therefore the picture the students saw on their paper was not clear. After the students expressed how the words and problem were confusing to them, the teacher showed them the colored picture on the right side (below) from the text book.

Teacher: “Look at this picture now, does the picture help you understand the question better?

Students: “Yes.” “I know what that is, it’s a can that has corn.” “I’ve seen these on farms - they have corn in them”.

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[Diagram of a silo with dimensions: 40 ft, 20 ft, and corn]
Teacher: “Read part (a) again, can you tell me how you would solve part (a)?”

Students: “What is the distributive property?” “I don’t get this.”

Teacher: “Do you know what the distributive property is?”

_The teacher waited till everyone had a chance to respond before explaining the distributive property._

Students: “Yes.” “No.”

_Some of the students guessed and others wrote their answer on their paper. Two students notice all the variations of the Distributive Property posted on the wall and wrote the following answer on their paper:_

_Student 1 wrote: w x 400 + 4400; Student 2: (40-4400) w. The other three students said nothing. But two of them wrote the following on their paper: 4400 x 4 – d, w = 4400 (40 – d)._

_The teacher wrote on the board: w = 4400(40 – d), and reminded the students of how the Distributive Property works: a (b - c) = ab - ac then wrote: w = 4400(40) – 4400d._

Teacher: “Now, calculate part (b)”

Students: “w = 176,000 – 4400d”, “171600”, and “176,000 – 4400”.

_The teacher reminds the students how to use substitution to calculate: w = 176,000 – 4400 x 15._

Students: “w = 110,000.”
Teacher: “What does 110,000 mean?” “What are we looking for?”
Student: “Pounds.”

The teacher wrote: lbs. next to w = 110,000. (Note: students struggle with remembering to label units of measurement).

Teacher: “Now find the answer to (c)” There is a pause, the students look at the teacher questioningly.

Teacher: “How many cows are there?”
Student: “100.”

The teacher waited, when there is no other response, the teacher asks “What math operation do we use to determine how much corn the cows will eat?” One student says “times” another says “divide.”

Teacher: “Yes, divide the amount of corn by the number of cows. How many pounds will each cow get?”
Student: “1100!”

Teacher: “How much corn does a cow eat in one day?”
Student: “10 pounds a day!”

Teacher: “What should we do with the 10 pounds?”
Students: “Divide!”

Teacher: “How many days will the 10 pounds last?”
Students: “110!”

The students did not understand what the 110 meant. The teacher paused for student response. The students were quiet as they waited for the teacher’s next question.

Teacher: “110, represents the days, how many days in a month?”
Student: “30.” “Or about 30.”

Teacher: “Let’s use 30 days per month. About how many months is this?”
Student: “3.6666…”
Teacher: “So about how many months?”

Student: “3”

Teacher: “3? What about the point 6?”

One student: “4, about 4 months.”
Teacher: “So about four months, 110,000 pounds of corn will feed all these 100 cows. How many pounds will be needed to feed the cows for one year?”

*The students did not know how to start the calculation.*

Teacher: “How many months in a year?”
Student: “12”

Teacher states and writes: “Take 12 months and divide by 3.6, the months you calculated 1100 pounds would feed one cow.”

Students: “3.3”

Teacher: “What should we do with this number?” The students did not say anything.

Teacher: “Well if 1100 pounds feeds one cow for 3.6 months, and 12 months divided by 3.6 equals 3.3, then this is how many times 1100 would need to be calculated to feed one cow in one year”

Student: No response.

Teacher: “How do we figure out how many pounds this is per year for one cow?”

Student: “Multiply?”

Teacher: “Yes, multiply 1100 times 3.3. This will be the amount of pounds needed to feed one cow in one year. Or we could take 3.3 times 110,000 to calculate the amount of corn needed to feed 100 cows in one year. If 100 cows are fed with 110,000 pounds of corn for 3.6 months, then 3.3 times of the year times 110,000 pounds will feed 100 cows for one year”.

One student: “This does not seem right. I got 363,000 pounds?”

*Teacher states as: 363,000 lbs is written on the chalkboard, “This is going to feed the cows for the whole year. Remember each cow eats ten pounds a day.”*

Student: “That’s a lot of corn.!”
Teacher: “If this is how much they will eat in a year, let’s calculate how much it will cost for one pound. Let’s say it cost $6.50 per pound. How would we calculate the total?”

Student: “Multiply.” “2359500.” “This is really big!” “That’s a lot of money!”

Teacher: “Well, what do you think these cows might be used for?”

Student: “Meat!”

*Before the bell rings, the teacher asks the following question as the students’ papers are collected:* “How much do you think each cow weighs and how much they are sold for per pound, remember cows weigh close to a ton?” The students think about the process and numbers as they turn in their papers.

One student says “Oh…”