CASE-STUDIES OF TEACHERS COLLABORATING TO IMPLEMENT A CULTURALLY-RELEVANT PROBLEM-SOLVING RICH MATHEMATICS UNIT IN FOUR CLASSROOMS IN THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS

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I chronicled the journeys of four teachers in three elementary schools in the Commonwealth of the Northern Mariana Islands (CNMI). To support the teachers in the implementation process, I created a series of focused collaboration sessions for them. These sessions first introduced the teachers to the idea of ethnomathematics and the potential of adopting culturally-relevant approaches, and later provided support during implementation. In order for me to understand the impact of the collaboration sessions and the implementation process on the teachers' beliefs about mathematics, teaching and curriculum, I created four case studies, one for each teacher, and employed cross-case analysis to form my conclusions. My analysis of the case studies showed that the teachers believed that the focused collaboration sessions and the implementation process effectively changed their teaching, their attitudes and knowledge of mathematics, and their understanding of curriculum. I recommend that others adopt a similar focused collaboration approach as a form of professional development for teachers interested in different approaches to teaching mathematics and developing curriculum.

Keywords: Problem-solving mathematics, ethnomathematics, Saipan, CNMI, teachers, case study
TABLE OF CONTENTS

Abstract .............................................................................................................. ii
Chapter 1. Introduction ...................................................................................... 1
   Rationale for the Study ................................................................................... 1
   History of Education in the CNMI ................................................................. 1
   Current CNMI Curriculum ............................................................................ 4
Chapter 2. Literature Review ............................................................................ 8
   Problem-Solving Rich Mathematics ............................................................... 8
   Culturally-Relevant Mathematics ................................................................ 11
Chapter 3. Methodology .................................................................................... 15
   Purpose of the Study ..................................................................................... 15
   Methods ......................................................................................................... 15
Chapter 4. Outcomes of the Study ................................................................. 20
   Study Participants ......................................................................................... 20
   Procedures and Data Gathering .................................................................... 21
   Limitations of the Study ............................................................................... 25
The Case Studies ............................................................................................... 26
   Introduction .................................................................................................. 26
   Case Studies ................................................................................................ 26
      First grade teachers .................................................................................. 30
      Fourth grade teachers ............................................................................. 32
   Reflection session in October with all teachers ....................................... 33
      Focus on first grade teachers ................................................................... 33
      Focus on fourth grade teachers ............................................................... 36
      First grade planning sessions ................................................................. 38
      First grade implementation of unit: Heidi ............................................. 45
      First grade implementation of unit: Tara .............................................. 50
      First grade implementation of unit: Collaboration Session 1 ............. 51
      First grade implementation of unit: Heidi ............................................. 56
      First grade implementation of unit: Heidi and Tara ............................ 60
      First grade implementation of unit: Tara .............................................. 61
      First grade implementation of unit: Collaboration Session 2 ............. 62
      First grade implementation of unit: Heidi ............................................. 64
      First grade implementation of unit: Tara .............................................. 67
      First grade implementation of unit: Collaboration Session 3 ............. 73
      First grade implementation of unit: Heidi ............................................. 80
      First grade implementation of unit: Tara .............................................. 81
      First grade implementation of unit: Collaboration Session 4 ............. 87
      First grade implementation of unit: Heidi ............................................. 90
      First grade implementation of unit: Tara .............................................. 92
      First grade implementation of unit: Collaboration Session 5 ............. 95
      Fourth grade planning sessions ............................................................... 97
      Fourth grade implementation of unit: Roxy ......................................... 99
      Fourth grade implementation of unit: Mindy ....................................... 99
      Fourth grade implementation of unit: Collaboration Session 1 ........ 100
      Fourth grade implementation of unit: Roxy ......................................... 101
# Table of Contents

Fourth grade implementation of unit: Mindy ................................. 104
Fourth grade implementation of unit: Collaboration Sessions 2 & 3 ... 105
Fourth grade implementation of unit: Roxy .................................. 107
Fourth grade implementation of unit: Mindy ................................. 110
Fourth grade implementation of unit: Collaboration Session 4 ....... 113
Fourth grade implementation of unit: Roxy .................................. 113
Fourth grade implementation of unit: Mindy ................................. 114
Fourth grade implementation of unit: Collaboration Session 5 ...... 115
Fourth grade implementation of unit: Roxy .................................. 115
Fourth grade implementation of unit: Mindy ................................. 117
Themes ...................................................................................... 119
  Problem-solving rich mathematics ........................................... 119
  Questioning techniques ............................................................ 120
  Manipulatives ........................................................................ 126
  Enduring understandings ....................................................... 135
  Cultural pit stops .................................................................... 143
  Confidence .............................................................................. 147
Chapter 5. Discussion and Conclusions ........................................... 154
  Revisiting the Case Studies ..................................................... 155
  The Role of Culture .................................................................. 157
  My Participation and What I Learned ....................................... 159
  Final Thoughts ....................................................................... 160
Appendices ................................................................................... 162
  Appendix A ............................................................................ 162
  Appendix B ............................................................................ 164
  Appendix C ............................................................................ 170
  Appendix D ............................................................................ 171
  Appendix E ............................................................................ 172
References ..................................................................................... 173
CHAPTER 1. INTRODUCTION

Rationale for the Study

Considerable research in the area of ethnomathematics emphasizing the use of culturally relevant and problem-solving rich mathematics over the past several decades has been studied in many parts of the world. In the Commonwealth of the Northern Mariana Islands CNMI, no research that links local, Chamorro culture and problem-solving rich mathematics teaching and learning has been conducted. Therefore, it is relevant to conduct an exploratory study at this point in time. Increased knowledge regarding the exploration of teacher perceptions, attitudes, and work ethic will help future researchers, teachers, and administrators as they work towards understanding the place of problem-solving rich ethnomathematics in the CNMI. This research is focused on 4 teachers in the CNMI whose journey, as they collaborate to implement a problem-solving rich, ethnomathematics unit, will be chronicled in case studies.

History of Education in the CNMI

In addition to those changes that occur during implementation, curriculum is inevitably affected when different nations govern and impose their ways of thinking and philosophies. “(C)urriculum does not ‘come alive’ until it is enacted and in the process of teaching and student learning” (Lipka et al., 2005). Education in the Marianas implicitly existed during the pre-Spanish era because, according to “History of the Northern Mariana Islands”, as the death rate of men escalated during the Spanish era, the knowledge of constructing the latte and making pottery ceased. Canoe building and navigation knowledge began to fade.
However, the Spanish did not let the education of the natives end. Some Chamorro children were allowed to go to school to learn to speak and write Spanish. These children attended school in Agana, Guam. When the Chamorros were allowed to return to Saipan, Tinian, or Rota, schools began to materialize in the major villages. The forced move of the Chamorros made by the Spanish, created some conflict between the Chamorros and Carolinians when the Chamorros of Saipan, Tinian, and Rota were allowed to return. Upon their return, primarily in Saipan, the Chamorros found the Carolinian people residing in their home. The Carolinians had traveled from the outer islands of Chuuk and Yap and found Saipan, an uninhabited island, and called it their home.

The Spanish sold the Marianas to Germany in 1899. George Fritz, a German citizen and governor of Saipan, established public education in Garapan (Saipan), Tanapag (Saipan), and Rota in April 1900. School was taught in Chamorro and Carolinian. When the Carolinians could speak Chamorro, they were moved into the classrooms with the Chamorro children. Education was compulsory for all children ages 7 to 13 by 1906. By 1912, 385 students were enrolled in school. After age 13, boys learned a trade. They were expected to contribute to the community. Fritz believed that education was utilitarian in that the natives needed to learn to become productive members of their society (Farrell, 1991).

In 1914, the Japanese seized Saipan and the Marianas. The Japanese established compulsory education for Chamorros and Carolinians. They had to attend three years of elementary school with a focus on having the natives learn the Japanese language. Other subjects were taught but the principle purpose for education was to create an army of workers either as servants, skilled laborers,
or, if an individual could understand Japanese, a minor official posting. The Japanese did not view the natives as equals and stifled opportunities for career growth. When the United States of America seized the Marianas in a World War II battle in 1944, more changes to the education of the native people occurred (Farrel, 1991).

In 1944, an American education program began. Books were prepared in English and Japanese: vocabulary lists were written in Chamorro and translated into English and another set of vocabulary lists were written in Japanese and translated into English. Vocational education also existed for farming, sewing, and woodworking. In May 1946,

a directive was issued for uniform public education in Micronesia... to help the islanders become more self-reliant, to encourage agriculture, mechanical arts, and local trade, and to instill respect for and loyalty to the United States by teaching the history, customs, and ideals of America. (Farrell, 1991, p. 490)

In 1951, the high commissioner of the Marianas stated that

(t)he objectives of elementary education have remained the same, namely: Preparing inhabitants to conduct their local government, trade, and industry; improving standards of health and hygiene; improving food and production methods; promoting literacy in the local language, knowledge of the history of the area, skill in the arts and crafts; and providing instruction in the English language. (Farrell, 1991, p. 411)

Additionally, schooling was offered at the secondary level to some students. These students had to travel to Chuuk, Guam, Fiji, Hawaii, or the United States
mainland. The Naval Administration (the governors of the Marianas) and later the Trust Territory Administration offered scholarships for those students who wanted to pursue their college education. The goal of secondary school, according to Farrell (1991) “was a gradual reduction in the number of American civil-service employees in the trust territory” (p. 491) with an emphasis in teacher training and other vocational-education programs.

As is evident in this history, curriculum goals in education in the Marianas have changed with one administration to the next. The native Chamorros educated their young with the utilitarian purpose of continuing certain trades (like latte construction), the Spanish educated the natives with the hopes of reforming their heathen ways and making them more “civilized” by teaching them Spanish, religion, and modesty, the Germans educated the natives with hopes of instilling in them good work ethic and a desire to save money, the Japanese educated the natives with hopes of teaching them a foundation necessary to enslave them to do their bidding, and finally, the United States educated the natives with hopes of teaching them self-reliance.

**Current CNMI Curriculum**

The current CNMI Public School System (PSS) became autonomous from the central government in 1988 with PSS acknowledging its foundations in 1947 when the Naval Administration began public school at the internment camps. All former ideals and goals of curriculum were discarded. It became transparent that the U.S. had specific curriculum goals for the people of the Marianas through Admiral Spruance’s directive for naval civil government by President Harry S. Truman:
Directive #12: Educational programs shall foster and encourage instruction in the local language and history and in the arts and crafts. Instruction in the English language for islanders of all ages is a prime necessity but this is not to be considered as discouraging instruction in the local languages and culture. Vocational training in trades, skills, agriculture and home-making as suited to particular locales should be geared to the capacities of the islanders. (Farrell, 1991, p. 515)

As time progressed and the Naval Administration gradually released its control of the government and the education in the Marianas, more and more local residents became the teachers in the schools. R. Sablan (personal communication, November 5, 2010) relayed that these teachers were given textbooks by the Department of Education (PSS now) and told to teach what was in the book. According to J. Quitugua (personal communication, November 1, 2010), in the late 1980s, curriculum leaders saw the need for more curriculum guidance and created a book of goals and objectives. In mathematics, these goals and objectives were inspired by the National Council of Teachers of Mathematics (NCTM) standards. This book was later replaced by the PSS Standards and Benchmarks.

In 1998, PSS included its teachers in the refining of curriculum standards through leadership teams. Currently, the leadership team is called the Learning Community. Team members sit and mull over current standards and benchmarks and decide on state-wide assessment. “Back then we were looking at the math standards (NCTM) and those clusters were recommended. The Pacific Standards also followed the same clusters” (J. Quitugua, personal communication, September 29, 2010). The clusters Quitugua speaks about are standards and benchmarks for students in K-2, 3-5, 6-8, and 9-12.
PSS used local experts in the field - our very own teachers, guided by our ACIS (then Rita Sablan) and the Math Specialist. At around 2002, or earlier the recommendation to have the standards and benchmarks reviewed again was critical due to the enormous numbers of benchmarks and reality of implementing was a challenge - the concern on depth over breadth with the content standards and the recommendation to put the benchmarks by grade level rather than cluster. McREL then came into the picture and facilitated the process across all contents: ensuring clarity on each benchmark, avoiding duplicity, and emphasizing mastery or proficiency on the benchmarks - "less being more". (J. Quitugua, personal communication, November 1, 2010)

Once the newer looking standards and benchmarks were printed by Midcontinent Research for Education and Learning (McREL), PSS hired Pacific Resources for Education and Learning (PREL) to send in an assessment specialist to aide in creating their own state-wide assessment of the benchmarks. Through this process, PSS hoped to attain higher achievement levels of students throughout the CNMI.

At present, the latest initiative by the governors’ of the USA through President Obama is the Common Core State Standards Initiative (CCSSI). The CNMI has agreed to adhere to the CCSSI. The standards and benchmarks in mathematics and English have already been modified to match the CCSSI. This change to full implementation occurred in SY 2012-2013.

The curriculum, at the onset of the United States taking over the governance of the NMI was utilitarian, ideals driven, and clear: teach the history in the arts and crafts in the local language, teach English, teach trades relevant to
the islands, and teach the American ideals and values. As time progressed, according to R. Sablan (personal communication, November 5, 2010) these curriculum goals got lost in the goals of the textbooks chosen by curriculum leaders at the central office, then as the times changed, curriculum leaders saw the need to become more Western in thought. Students were tested according to standardized tests such as the California Achievement Test (CAT) and later the SAT-9 and SAT-10. Instruction was delivered in English. Chamorro and/or Carolinian language classes were offered at the different public elementary and middle schools. Today, the curriculum is mostly a result of teacher input with each school deciding their Expected School-wide Learning Results (ESLRs). Content, however, is driven by the Board of Education approved standards, CCSSSI standards in mathematics and English. Chamorro and/or Carolinian language instruction continues but no school exists where content is taught in Chamorro or Carolinian.

The Northern Marianas Public School System has clearly deviated from the intent of the United States government at its time of overtaking control of the Northern Mariana Islands. This may account for the lack of interest and achievement in mathematics in the CNMI (Tudela, 2010). As such, it may be time to reflect on the original goals of placing an importance in culture and incorporate the research-based process standards of NCTM to improve interest, attitude, and achievement in the CNMI: a culturally-relevant and problem-solving rich mathematics curriculum is necessary.
Problem-Solving Rich Mathematics Curriculum

Problem-solving rich mathematical experiences exist in classrooms that incorporate the process standards of NCTM: reasoning and sense-making, problem-solving, making connections, communicating, and using representations in mathematics (Hiebert, 1999). Such classrooms are filled with students discussing their mathematical ideas, justifying their thoughts, and using a variety of manipulatives to illustrate ideas (Buschman, 2003). These classrooms rely on student discourse to gauge the progress of the learning and to decide on future lessons (Bray, Dixon, & Martinez, 2006). Lesson plans in such classrooms not only delineate the daily activities of the students but also include the questions that must be asked and anticipated in order to push student thinking and gain an understanding of student thinking (Wallace, 2007), (Heng & Sudarshan, 2013) and (Nebesniak, 2013). Teachers in a problem-solving rich mathematics classroom are typically seen observing the dynamics of the classroom, conversing with the students, and often as students become better problem-solvers, teachers step back and allow students to explore without interference, unless absolutely necessary (O'Donnell, 2006). After the period of exploration and student discourse, the teacher may call the class back together for group discussion. Teachers normally identify different types of thinking that were observed and ask those students or pairs to present their findings to the class for whole class discussion (Bray et al., 2006). Through these discussions, teachers can gain further insight into their students' thinking and quite possibly assist them in the decision on how to segue into the next lesson. These
discussions usually call attention to any difficulties students encounter for teachers to address (Sanders, 2009).

Recently, the Common Core initiative is the buzz in the CNMI. Framing the mathematical content are the eight common core mathematical practices (National Governors Association & Council of Chief State School Officers, 2012, pages 6-8):

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Achieve, Inc. reveal the history of the origins of the Common Core as follows:

In 2009, 48 states, 2 territories and the District of Columbia signed a memorandum of agreement with the National Governors Association (NGA) and Council of Chief State School Officers (CCSSO), committing to a state-led process - the Common Core State Standards Initiative (CCSSI).

Achieve partnered with NGA and CCSSO on the Initiative and a number of Achieve staff and consultants served on the writing and review teams. On June 2, 2010, the Common Core State Standards for English Language Arts/Literacy and Mathematics (CCSS) were released [1], and since then,
over 45 states have adopted the Common Core State Standards and are now working to implement the standards. (p.1, Achieve, Inc., n.d.).

The first four were inspired by the NCTM process standards (National Council of Teachers of Mathematics, 2010). In a letter to the NGA and the CCSSO (Kepner, 2010), NCTM commented:

The National Council of Teachers of Mathematics (NCTM) supports the basic goals and aims of the Common Core State Standards for Mathematics. NCTM has long advocated consistency and coherence in the mathematics curriculum—in Principles and Standards for School Mathematics (2000) and more recently in the 2006 publication of Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence, and in Focus in High School Mathematics: Reasoning and Sense Making (2009). The Council’s response to the public draft of the Common Core Standards reflects what we have learned in our long history of developing and writing K–12 standards for school mathematics.

The next set of practices (numbers 5–8) come from the National Research Council (NRC) (National Research Council, 2001). NCTM and NRC were important influences in the creation of the CCSSI in mathematics. The beliefs supported by both NCTM and NRC are reflected in the mathematical practices and as such, they are the driving force for improved mathematics education under CCSSI.

At the beginning of SY 2011-2012, the words “Common Core” entered into curricular conversations around PSS. In mathematics, leaders from Central Office started visiting the various school sites to ask teachers
to match up the current PSS mathematics benchmarks with the Common Core skill standards and do some rating of the standard in relation to the benchmark. This exercise was done to start the Common Core conversations at the school level so that when SY 2014-2015 arrived, all schools would be ready for full implementation of mathematics and English Common Core standards. During the last three Professional Learning Community (PLC) meetings during SY 2011-2012, the Common Core standards for PSS were mapped out for a school year, the design of the mathematics curriculum in the high school changed from Algebra 1, Geometry, Algebra 2 to Math 1, Math 2, and Math 3, the integrated approach to teaching the Common Core standards, and sample lessons that incorporated the Common Core standards were created to present to the Board of Education for their review, comments, and possibly approval. The last PLC meeting of SY 2011 – 2012 focused on the sample lesson. During this session, the high school geometry teachers focused on the Common Core mathematical practices to guide the sample lesson.

However, at the beginning of SY 2012 – 2013, it was announced that full implementation would begin that year and that the high school mathematics courses would remain as it has in the past with Algebra 1, Geometry, and Algebra 2.

Culturally-Relevant Mathematics

Ethnomathematics “is used to express the relationship between culture and mathematics” (308) (D’Ambrosio, 2001; Barton, 1996). Dr. Julie Kaomea frames ethnomathematics within the past, present, and future of the Hawaiian people (Kaomea, 2012). For this research project, it can include any aspect of the
past, present, future, or a combination of any of those elements. An ethnomathematics curriculum cannot be limited to the past because some of the children, especially the children not native to the islands of the CNMI may feel alienated and disjointed from the lessons. By connecting the past to the present and possibly to the future, all students can benefit from an ethnomathematics curriculum. Whenever a heterogeneous society exists, care must be taken to allow for entry points for every student. By linking the past to the present, all students can understand the context of the lesson and gain an appreciation for the indigenous culture.

Culture incorporates a people's beliefs, traditions, values, customs, and ways of life. This must be taught, it is not something one is born with (Wolcott, 1982). Dr. Katherine Aguon, a scholar from the island of Guam, argues that the purpose of education is to perpetuate the culture of the people and the place. She argues that in any society, the culture of the indigenous people must be perpetuated. In Saipan, that would be the Chamorro and Carolinian cultures (KUAM, 2011). The CNMI is also home to a large number of foreign contract laborers like the Filipino, Korean, and Japanese. The influx of these foreign contract laborers resulted from huge labor demands in the 1980s. In addition to the indigenous population and the contract labor population, some Americans from the United States of America call the CNMI home. Consequently, the culture in the CNMI is a mix of these various cultures in the present and the cultures of the past that influenced the Chamorro and Carolinian people as a result of the different occupying countries during the course of the history of the Marianas.
I am of Chamorro descent. My family is Ada, Atalig, Sablan, Taimanao, Diaz, Cabrera, Manglona, Camacho, San Nicolas, Tudela, Pangelinan, Reyes, and Borja. I understand that although I am considered indigenous on the islands, my blood that flows within my veins is a mixture of various genetic influences starting with my Chamorro ancestors, then during the Spanish occupation, my great- (maybe 3 or 4 “greats” ago) grandfather was a Spanish priest who, along with my great- (x3 or x4) grandmother, the maid of the chancery, gave life to the next person in my lineage who was no longer a pure Chamorro (Borja, 2012), (ancestry.com, 2012). This is the history of many people on our islands. However, we consider ourselves Chamorro.

Dr. Katherine Aguon explains that the concept of Chamorro culture is rooted in *inafa‘maolek* or making good. She identifies six concepts in the language that embody the culture: (1) *respetu* (respect), (2) *manginge* (paying respect to elders), (3) *mamahlao* (being ashamed), (4) *chenchule* (social debt), (5) *che’lu* (siblings), and (6) *påtgon* (children) (Aguon, 2011). These concepts in the Chamorro culture revolve around a community that is not limited to the nuclear family but extends to aunts, uncles, cousins, godparents, and grandparents. As such, mathematics that focuses on the individual and individual efforts may be an impediment to meaningful learning in the classroom. A culturally-relevant, problem-solving rich mathematics curriculum infuses the culture of the place with the problem-solving rich mathematics curriculum (Bucknall, 1995). Its intent is to make education more meaningful for students (Agbo, 2001). Through a culturally-relevant curriculum, students can more easily create mathematical meaning via experiences that are real to them (Lipka, et al, 2005).
Culturally-relevant curricula, in the context of the Chamorro culture, incorporates the 6 concepts delineated by Dr. Aguon through either a common, regularly practiced Chamorro cultural activity or a historical Chamorro activity. For example, a regularly practiced Chamorro cultural activity revolves around the preparation of food for a fiesta. Chamorros and non-Chamorros of the islands can associate with the different foods and the efforts necessary for the preparation for the fiesta. An example of a historical activity includes the building of a latte-stone. These activities are examples from which the context that a problem-solving rich mathematical lesson can be derived.

Bucknall (1995) had defined a successful indigenous class to include components of culturally-relevant mathematics and a problem-solving rich mathematical experience. As with the other researchers before and after her such as Hiebert (1999), Wallace (2007), and Buschman (2003), she defines a problem-solving rich mathematical curriculum to include lessons that challenge the students to communicate, problem solve, reason and make-sense of their problem, make connections, and use representations to engage in the mathematics. It is my intention to frame the thought-provoking aspect of mathematics within the context of the Chamorro culture.

In order for this culturally-relevant and problem-solving rich mathematics curriculum to be successfully implemented, teachers must be fully vested in the curriculum. They must be involved in the planning, implementing, and revising of the curriculum unit (Willoughby, 2010), (Lipka et al., 2005).
CHAPTER 3. METHODOLOGY

Purpose of the Study

The purpose of this case study is to describe what happens when teachers collaborate to implement a mathematics curriculum designed to be culturally relevant and problem-solving rich. The objectives of this research project are: 1) create a culturally-relevant, problem-solving rich mathematics unit plan, 2) provide teachers with opportunities that support the implementation of the developed unit plan, and 3) understand the process and results of collaboration and unit plan implementation from the teachers’ point of view. The creation of the unit plan initially came from me. However, through the pre-implementation phase and the implementation phase, the teachers were given much leeway to make the unit plan their own through revisions.

Methods

To find out what happens when teachers collaborate to implement a mathematics curriculum designed to be culturally relevant and problem-solving rich, I observed teachers directly and indirectly as they implemented their lessons, I participated in the collaboration discussions prior to the implementation, during the implementation, and after the implementation, and I read their thoughts during implementation in a journal I had asked them to keep. By creating case studies of the four teachers, I examined the reactions and interactions of teachers through my careful observations of their planning, implementing, and reflecting.
Consequently, my study was exploratory in nature. It aimed to understand how teachers reacted and interacted to culturally-relevant mathematics as introduced by me through our pre-sessions. Case studies, as Hatch (2002) relates, are relevant for researchers trying to investigate a specific phenomenon within a specific context. This is precisely my goal: investigate what happens when teachers collaborate to implement a culturally relevant, problem-solving rich mathematics curriculum.

Because my study aimed to explore the reactions and interactions of teachers as they collaborate to implement the culturally-relevant mathematics, I framed my study using a combination of paradigms and thereby act as a bricoleur (Tobin, 2006), that is, a person interested in creating a workable synthesis of different ideas. Through my readings, I had not found one particular paradigmatic lens that would best tell the story of the teachers in my research study. I incorporated an indigenous framework where respect, reciprocity, and responsibility were vital components to my research process (Wilson, 2008) while I incorporated a social constructivist paradigm that melds with the indigenous framework to make sense of the occurrences in relation to the teachers in the study and in relation to their relationship with one another (Kalina & Powell, 2009). The rationale behind the collaboration among and/or between the teachers falls within both the indigenous and the social constructivist framework. Through collaboration, the teachers were given an avenue to construct their understanding of the unit plan originally created by the researcher and make it their own. As teachers in an indigenous context (the Pacific island of Saipan), I assumed that they understood and lived the ideals of respect, reciprocity, and responsibility. I understood that the construction of meaning by the participants
would be affected by my involvement during the initial planning phase and during the collaboration sessions: the collaboration between and among the teachers included the monthly summer sessions where the teachers reviewed and revised the curriculum, the session during a Professional Development day, and finally the sessions during the implementation of the lessons. During the monthly summer sessions, the teachers collaborated as they discussed the lessons of the unit, discussed how they anticipated their students would interact within the structure of the lessons, made suggestions on how to improve the lessons, and discussed their willingness to try something different in their classrooms. During the reflection session at one of the Professional Development days, the teachers shared how the summer session interactions affected their teaching, thus far, if at all. When teachers expressed frustrations as their reflections, other teachers in the group offered suggestions to try and alleviate the frustrations. The biggest collaboration sessions occurred during the implementation phase of the lessons. On the same day as implementation but after school, the teachers would meet to reflect and discuss the day’s lesson and the next day’s lesson. The teachers would share concerns and suggestions with each other. Often, changes to the lesson for future use and changes to the next day’s lesson, based on the collaboration session would occur.

As a social constructivist indigenous researcher, my role was to create the framework for the collaboration to occur, observe and participate in the planning and reflection process, and observe during the implementation process. I had to be cognizant of the fact that I was asking teachers to allow me to visit their classrooms. I knew that I was a visitor in their world and had to respect their
thoughts and ideas. The participants were also cognizant of the fact that I too was a teacher of more than 10 years in the school system.

To conduct the study, I: 1) observed and participated in the collaboration and reflection process of the creation and implementation of the said curriculum, 2) observed teachers as they implemented the lessons, and 3) analyzed the reflections, collaboration sessions, interviews, and classroom occurrences of the teachers involved in the research and the implementation of the unit plan.

Part of my analysis occurred on the same day of implementation, if I observed the classroom directly. After the observation, on my way back to my classroom, I would turn on my digital voice recorder and share my thoughts about the lesson. Initially, I wanted to transcribe the video and audio recordings immediately after each session but time did not allow me to do this because I found that transcribing was time consuming. It often took me two times to three times as long as the recordings to transcribe every detail and record my written notes. Sometimes, it was difficult to discern who was talking when many people talked at once. I transcribed any recordings I made and any recordings teachers made. Each chunk of transcription was about an hour recording. While transcribing, I would record any observations and queries I had of the hour. Since I transcribed every detail of the observations and recordings, it was fairly simple to record the details of the cases when I reported what had occurred in the classrooms with each teacher. If recordings weren’t available due to technical difficulties, I solely used my notes (if I observed the classroom) and/or the teacher’s daily reflections to reconstruct the day.

Analysis of the data required that I review all my notes (from direct observation and from the transcribed data) and look for themes. Through my
participation in the study, I quickly noticed certain themes and searched for key
words in the transcriptions and in my notes to justify or refute my conjectures. I
cut and paste all items I found and put them together (copy and paste) to better
analyze my data. I performed some cross-case analysis when I noticed certain
themes occurring across grade-levels and even across teachers of different grade
levels. Again, I searched for key words in the transcriptions and in my notes to
justify or refute my conjectures. Whenever my findings linked to what I found
from my literature review, I referred to the review to support my findings.
CHAPTER 4. OUTCOMES OF THE STUDY

Study Participants

According to the CNMI PSS Facts and Figures SY 2011 – 2012 (CNMI, 2011), there are currently 464 public elementary and secondary teachers in the CNMI. Teacher participants are a convenience sample: they comprise of teachers I know or worked with when I taught in an elementary school on Saipan (School X), a teacher I met prior to the study, and teachers recommended by other teachers. I began with the group of teachers from School X because I had already built a trusting relationship with them. My husband mentioned my study to some of his teacher colleagues and two of them indicated interest in joining the project. I invited them into the group. One of those teachers happened to also be a former colleague of mine from School X. He wanted to help me with my study and recommended a teacher from his school to join him in the project. I invited her. During the summer, on my way to an education conference in Pohnpei, I ran into a teacher from PSS. We started to talk and the topic of my study came up. In the end, she told me she was interested in the project and would like to be a part of my study. I invited her. At the onset of my study, eight participants were invited to join. Although I intended to do three to four case studies, I suspected that subject attrition would occur leading me to keep all eight participants. After the second meeting, three of the participants were informed by their principals that they would be changing grade levels in the upcoming school year. Consequently, those three left the group. After the third meeting, 1 participant, decided not to continue with the study for unknown reasons. Participants were given the option to decline participation at any time. By August 2012, I was left
with the teachers that are the subjects of this study: two first grade teachers and two fourth grade teachers.

These teachers come from 3 different public elementary schools. They are all female.

**Procedures and Data Gathering**

Participation in the research began in May 2012 and continued until December 2012 for one teacher and until February 2013 for the other three teachers. Their participation included monthly meetings of about an hour in length that supported the implementation of the ethnomathematics, problem-solving rich curriculum. The first meeting in May was an informational meeting where the intent of the study was made clear and discussion about their roles in the study ensued. In June, we met as a big group where the teachers played the part of the students in the 4th grade curriculum unit. In July and August, I separated the 1st grade teachers from the 4th grade teachers to begin to analyze the curriculums intended for implementation. We did not meet in September but met in October for two hours to reflect on any changes that we had seen in our teaching due to our collaboration sessions. Originally, the plan was for the 4th grade teachers to implement their curriculum unit in November or December. Due to some circumstances, one fourth grade teacher implemented her curriculum unit in December and the other implemented in February 2013. The 1st grade teachers implemented their unit in January 2013. During the implementation phase of the study, only the affected teachers met daily for collaboration and reflection. It is important to note that when one of the 4th grade teachers implemented her lesson in February, collaboration and reflection only occurred between the 4th grade teacher and the researcher. The other 4th
grade teacher opted not to participate in the collaboration and reflection sessions. The daily collaboration sessions occurred for about 1 hour. The daily collaboration sessions ended on the last day of the unit.

Consent forms from the teachers and the parents of the students in the affected classes were obtained for the express purpose of this study. Assent was acquired from the students who were being observed and/or recorded.

The purpose of the planning sessions that occurred prior to the implementation of the lessons was two-fold: 1) Allow teachers access to the lessons for a variety of reasons and 2) Provide a venue for the 4th grade teachers to meet and possibly get to know each other and allow me to observe the interactions between the grade-level teachers. Teachers need to be thoroughly involved in the curriculum in order for them to implement it in its intended way. Although I had a vision for how I wanted the curriculum implemented, I was open to the possibility of it being changed before implementation. I wanted the teachers who were going to implement the lessons be given a chance to put their voice into the lesson.

All the teachers experienced the 4th grade curriculum unit in one 2-hour session where I acted as the teacher for the session and the teachers were my students. The 5-day lesson was condensed into 2 hours with the last day of the lesson omitted due to time constraints. After the session, the 4th grade teachers met for two hours the next month to reflect on their experiences with the lesson and make changes as necessary. The 4th grade teachers met one more time the following month to further refine the lessons in the unit.

The 1st grade teachers met for two hours to review the lesson and reflect on its effectiveness. At the next meeting, they met to further refine the lesson.
In October, all four teachers met to reflect on how the planning sessions had affected their teaching thus far, if at all, through the eight mathematical practices of the Common Core. This session was two hours in length. This was the last whole group meeting.

The plan was to have the two grade-level teachers teach their lessons concurrently. This did not occur for the 4th grade teachers. One teacher, Mindy, taught her lesson in February. Roxy proceeded as planned. Roxy asked if I wanted her to wait so that she and Mindy could teach concurrently but I told her that would be unnecessary as I did not want to burden her with an unscheduled change. Consequently, an opportunity to explore another facet of the collaboration process that I had not anticipated presented itself, the lesson study approach to improving teaching.

The lesson study approach to improving teaching originated in Japan. It focuses on the teaching and the lessons rather than the teacher (Hiebert & Morris, 2012). Through this experience, teachers can gain significant professional benefits (Lewis, Perry, & Hurd, 2004). The process of lesson study can be thought of as a type of research in and of itself (Lewis, Perry, & Murata, 2006). Therefore its place in a research study can be invaluable. Since the intent of this study did not include the lesson study approach, the way that it presented itself in this study is not directly in line with the required steps necessary to mimic Japan’s lesson study approach according to Fernandez & Chokshi (2002). However, it is relevant to discuss the results of this particular case as referenced by Fernandez (2002).

The 1st grade teachers, Tara and Heidi, taught the lessons of the unit concurrently in February. Like the 4th grade teachers, I asked that they record
their teaching focusing on their conversations with the students. I was able to conduct observations of the implementation of the lessons of Heidi in first grade, Roxy in 4th grade, and some of Mindy in 4th grade. All teachers were able to video or audio record most of their lessons. Some lessons did not get recorded due to technical difficulties.

In the 1st grade, Heidi had video recordings of day 1 and day 2 in the classrooms. Due to technical difficulties, only an audio recording of day 3 was acquired and no recordings of days 4 and 5 were obtained. Tara provided me with video footage of days 3 – 5. Since Tara’s camera was manned by no one, Tara placed it in a space in her classroom to capture her teaching on the rug. For the most part, her camera remained in one position during its entire recording time.

After each lesson was taught, the teachers of the grade-level (with the exception of when Mindy taught her lessons) would meet with me to reflect on the lesson and plan for the next lesson. This occurred until the completion of the lessons in the unit. These reflection/collaboration sessions were audio recorded. Additionally, the teachers were asked to provide me with a written daily reflection that was left in a shared dropbox folder. I had also asked each teacher to provide me with a background information sheet that they could email to me or leave in the dropbox folder.

In summary, the results of the study emerged from video and/or audio recordings of pre-implementation, implementation, and collaboration sessions, field notes of direct observations of implementation of lessons, written self-reflections by the teacher participants in the study, background information provided by the teachers, and an interview after the final collaboration session.
using two sets of questions from an NSF study tracking the progress of teachers as they implement culturally relevant lessons (see Appendices A and B).

**Limitations of the Study**

Because the study follows the journeys of four teachers, it is limited in terms of its generalizability. Furthermore, the four teachers come from a very specific population: grade 1 and grade 4 female teachers from the public school system. The cultural focus of the units in both grades is limited to the Chamorro culture and does not consider the other indigenous culture of the CNMI: the Carolinians. Therefore, the study does not try to generalize to the teacher population of the CNMI.

While I chronicled the journeys of the research participants, I am cognizant that their journey includes my journey as well since I am not only the researcher but also a participant. As a participant researcher, I struggled, especially in the beginning with Roxy since she was the first teacher I observed, with my identity as a teacher and as a researcher. I believe that my role as a teacher helped the teachers with the level of confidence they had in me and my project. As a researcher, I was able to see the growth of the teachers as their journey progressed. Although I learned that collaboration with just me, the researcher, was not sufficient in Mindy’s case because she was not satisfied with her students’ level of understanding at the end of the 9 days. She stated that she would do the entire 9 days again the following week. I would not recommend replicating this part of my study because of the struggles I witnessed with Mindy.

Additionally, my relationship with these teachers seems to explain the willingness of these participants to give the time and effort expected of them to participate in my study. It serves as a bias in favor of my study. If I had done this
with teachers who were assigned to me or were teachers who preferred to work alone, the outcome of my sessions and possibly the lessons would likely have been different.

**The Case Studies**

**Introduction**

The cases below are organized starting with an overview of our meeting timeline. I follow with a brief description of each teacher in their respective grade-level and I share the reflection session in October to provide the reader with some background information about each teacher. The four teachers are each identified with a single first name. Teacher and student identifiers are pseudonyms. Then, I present the stories of the separate grade-levels beginning with the work we had done prior to the implementation of the lessons. During the implementation of the lessons, I separate each teacher into a unique case. Then, I continue the grade-level story with the post-implementation collaboration sessions of the lessons. Grade 1 and grade 4 students who could be identified in the video or audio recordings are named with two upper case letters like JZ. Students who could not be identified (only a voice was heard and the teacher didn’t name the student) are identified with only one upper case letter like A. I end my cases with the themes that emerged from each grade-level and/or each teacher.

**Case Studies**

The first grade unit and the fourth grade unit in the appendix (Appendices C and D, respectively) are the revised versions of the units. They were revised after the teachers implemented the lessons as they were originally planned. Through the stories of the first grade teachers and the fourth grade
teachers, the reader will be able to see the unit as it was intended and how it morphed as a result of the trial and discussions. The reader will also be able to see how collaboration affected the implementation of the lessons.

Heidi and Tara, the first grade teachers, implemented their lessons concurrently (same days and same time period). Consequently, I was only able to observe Heidi on a daily basis. My telling of Tara’s story is a result of her video recordings, her reflections during our collaboration sessions, and her written reflections. Heidi and Tara work at the same school so I was able to observe Tara when both Tara and Heidi brought their students outdoors for day 2 of the lesson.

Prior to the implementation of the first grade lessons, we met twice to plan the lessons for the unit and two more times with the entire group (not including the initial informational meeting).

Roxy and Mindy, the fourth grade teachers, implemented their lessons separately. Our plan called for implementation in December 2012. Mindy was unable to implement in December due to her school’s curriculum map that put the content we were planning in the third quarter. Roxy implemented her lessons as planned and Mindy implemented her lessons in February 2013. I observed Roxy for six out of her eight days of implementation. I was not able to observe Mindy daily but I have all 9 days of her implemented lessons on video. I observed four of her nine days of teaching and have field notes of my observations. In addition to my observations and field notes of Roxy, I have video of her teaching days 2-5, and day 8 and she provided me with daily reflections of days 1-4. Missing video recordings are a result of technical difficulties. Each day after observing her lesson, Roxy and I would meet with
Mindy to discuss her lessons. Audio recordings of all these after school collaboration sessions were made. At the end of the unit, separate interviews with Roxy and Mindy were conducted similar to the ones conducted with Heidi and Tara.

During the first two planning sessions, I learned some things about Heidi and Tara with regards to their mathematical background, their cultural background, and their teaching styles. Although I worked with Heidi for 7 years and Tara for 9 years at their elementary school, my interactions with them were limited to staff meetings, accreditation meetings, and professional development sessions. We were colleagues teaching at different grade levels. I taught upper elementary while they taught the lower elementary students. Our sessions in May, June, July, and August illuminated some mathematics attitudes of these two teachers. Heidi was confident with her mathematics content and pedagogy. She was aware of the extent and limit of her mathematics knowledge and was eager to learn more. In one of our sessions, Heidi commented that she likes learning mathematics beyond what she teaches because it helps her see where her students are going with the mathematics and it can help her teaching. Tara was confident with her mathematics at the lower elementary levels. She readily admitted that although she was not very fond of mathematics, she was willing to learn more for the sake of her students.

From the May PD on the 4th grade curriculum unit, I could see that Heidi was inquisitive. She possessed many of the traits of an individual who used the Mathematical Practices in Common Core. She asked questions, critiqued the reasoning of her peers, looked for patterns, reasoned, and attended to precision. With new math activities, Heidi embraced the challenges and enjoyed seeing the
mathematics from a different perspective. Additionally, her connection to her culture became evident in her knowledge of the various fishes (in our language) and in her concern for aiding the Chamorro-Bilingual class become a better program in the schools, “It would be nice if you shared it (the story) with the Chamorro-Bilingual (class). They need more... they look for stories.”

From the first four planning sessions I hadn’t learned as much about Roxy and Mindy with regards to their mathematical background, their cultural background, and their teaching styles. Roxy and Mindy were quieter than Heidi and Tara at our collaboration sessions. There were two other 4th grade teachers at these early planning sessions and the most vocal was Betsy who later was no longer part of the project because she was moved to teach a different grade level. Betsy, Heidi, and Tara were the teachers who were my colleagues when I taught at one of our elementary schools. They seemed to be the most comfortable during our sessions.

My relationships with Roxy and Mindy were new when we started the project. I learned that Roxy likes to observe before speaking. She is open to trying new things and learning or refreshing her mathematics. She cares very much about the learning of her students and is very attentive to the details of the lessons. She adds to the collaboration sessions by asking questions about the practicality of items in the lesson. During the planning sessions, she never indicated that the teaching style proposed in the lesson was relatively new to her. She was always positive and willing to try.

Mindy was even quieter than Roxy during our sessions. She joined the group a session later than the rest. She shared that mathematics is not her strength and that was part of the reason she wanted to be part of the study: she
wanted to get some professional development in her teaching of mathematics. Mindy was most concerned about not knowing much about what the implementation of Common Core meant for her and her school. When we were discussing the possible implementation dates, she wanted to be sure that the dates coincided with the curriculum map that had not been created yet. Consequently, Mindy and Roxy implemented the lessons at different times of the school year.

As an indigenous researcher, my place and the place of the participants in my study are of utmost importance. Their place informs the reader of the context from which each participant comes and how that context may or may not influence the research. In this study, the curriculum used to report on what happens when teachers collaborate in an ethnomathematics curriculum with the focus on the Chamorro culture. Saipan is not comprised solely of Chamorro people therefore, understanding where each participant in my study comes from, can give further insight to the relationship between the participants and the researcher and the participants and their students within the context of the curriculum unit. The four teachers, Heidi, Tara, Roxy, and Mindy come from various backgrounds. The students in their classes come from a variety of backgrounds too (Appendix E).

**First grade teachers.** Heidi is a Chamorro who was born and raised on the island of Saipan. She highly values her culture and believes that in a lot of ways, it defines who she is. She wears jewelry that symbolizes our culture and teaches her children to speak the language. In her home and in her presence (even outside of her home), she requires her children speak to her in Chamorro. Her husband is a local jewelry maker: he is known for making beautiful pieces of
Chamorro jewelry. Whenever I see Heidi in the context of the research or outside of the research, we speak to each other in our native tongue and continue to do so unless we cannot find the words to express ourselves or are in the presence of individuals who don’t speak the language.

Heidi has been teaching for 13 years at the same school. She knew she wanted to become a teacher since the age of 8. She loves teaching. She believes that every child can learn and they each have their special way of learning. She believes that the onus is on the teacher to unlock the child’s best way of learning so that they can be successful in the learning process. She values patience, consistency, and persistency in herself as she teaches her students. She realizes that teaching and learning are processes and that perfection can never be achieved. She values mistakes as learning tools.

Tara has lived and taught in the CNMI for 23 years. She is a Caucasian from the state of Washington. She considers the CNMI her home because this is where she has made a home with her husband and her two boys.

When she was a senior in high school, she decided that she wanted to become a teacher. She enjoys teaching. Like Heidi, she believes that every child can learn. She believes that it is her responsibility to think of different strategies of teaching to enhance learning. She realizes that learning never stops and that people are always learning new things. She values professional development that can help her become a better teacher which would in turn impact her students’ learning. She has admitted that she is a “drill and kill worksheet type of person in terms of math: I teach, then allow them to practice” (Interview notes).
Fourth grade teachers. Roxy is Chamorro. Her parents are Chamorro and she was raised with many of the traditions, customs, and beliefs of the Chamorro culture. She was born in Saipan and lived there for most of her life.

Roxy has been teaching since August 2007 for a total of 5 years. She became interested in teaching during her high school years. During her sophomore and junior years in high school, she was a student in the school’s Teacher Academy program. Through the program she had the opportunity to enroll in teacher introduction courses at the local college. During this time, she was also afforded the opportunity to work with students as part of her field work. Her father was in the field of education and was highly supportive of her decision to pursue a career in education during high school and college. She loves her profession. She feels great rewards when she sees her students show progress. She enjoys creating lessons that will spark interest and create venues for meaningful connections. She believes that every child is unique and like Heidi and Tara, she believes every child can learn. She is aware that not all students learn the same way or at the same rate. She feels that it is the teacher’s responsibility to differentiate their instruction and tailor lessons to the varied learning styles and abilities of the students. Teachers need to work on providing numerous learning opportunities to meet students’ interests and also to keep them motivated about learning. She believes that the teacher is the facilitator in the classroom. Her role is to help guide students to become accountable for their learning and to build on their strengths, and work on areas that may need improvement. One of her personal goals is to have her students become more self-directed in their learning by the end of the school year. She encourages them to work towards achieving their full potential and applying it not only in school,
but also beyond the classroom walls. Finally, she believes in teaching the whole child. While she values academics, she also believes that teachers need to partner with families to help teach character. She believes that society would not only want academically advanced citizens but respectful ones as well. Her beliefs about teaching have earned Roxy the title of CNMI Teacher of the Year for 2011. Despite this accolade, Roxy believes that she has room for growth and constantly reflects about how she can be better.

Mindy was born and raised in the CNMI. She considers herself a Pacific Islander (Local). She did not share her ethnicity. She has been teaching in the CNMI for 8 years.

She has always envisioned herself as a teacher. As a child, she worked with younger children and in high school she babysat, tutored kids, and worked as an aide in some classrooms. She enjoys teaching but recognizes the challenges that come with it. She believes that students and teachers interact to create a learning environment beneficial to the student. She understands that education is an endless journey that allows for many growth opportunities for students and teachers.

**Reflection session in October with all teachers.**

**Focus on first grade teachers.** During the October session with the entire group, the teachers were given an opportunity to reflect on their mathematics teaching. I had asked them if they could share what they were doing in their classes at the moment to help their kids make sense of problems and persevere in solving math problems. Heidi responded with, “I did something different this year with the way I taught place-value. I went with the way Common Core explained it” (Pre-implementation audio collaboration session). She “flipped” the
way she normally taught place value: instead of telling kids where the places were and help them to understand those ideas, she gave them a richer experience in understanding the concepts of the ones and tens place. She called the activity, “Bundles of 10”. This experience provided the students with conceptual understanding of the place values and when she gave names to the place values, the students felt it was a natural extension of what they already understood. Prior to the activity, she instructed her students to count the sticks and bundle them with 10 sticks per bundle. She reflected that some of her students had a difficult time counting despite the fact that they counted every day. During the Bundles of 10 Activity, Heidi noticed her students “arguing”. They were justifying each other’s ideas about what to do with extra sticks outside of their bundles of 10. Heidi was pleased to hear her students reasoning.

During this October reflection session, Mindy talked about her students having difficulty with place value after Heidi had shared her success story. She shared about teaching her kids place value via the place value mat and identified the places for her students to help them understand the concept. I commented that teaching the mechanics of place value may not be enough to help the students understand the concept. At that point, Heidi chimed in suggesting Mindy try her activity because her students seemed to truly understand place value after the experience. Heidi revealed that she has always found value in being creative with her teaching but that sometimes, time constraints prevent her from doing more explorations in mathematics. After seeing the success in her Bundles of 10 Activity, she shared that she can see more value in an exploratory approach to teaching mathematics.
Combined, Tara and Heidi are inquisitive, resourceful, and reflective. Through my interactions with Tara and through our discussions, Tara’s disposition towards mathematics and mathematics curriculum became evident. Tara does not exude the mathematics confidence of Heidi. However, she shares Heidi’s desire for self-improvement. At each session, Heidi usually asked the questions that others were hesitant to ask. Her questions were always welcomed by others and sparked further discussion. She offered constructive criticism whenever necessary which caused me to further analyze the lessons and their intent. Because of her lack of confidence with mathematics, Tara was not as eager to try new approaches to mathematics. As a member of the study and as a teacher with a desire to improve, Tara was willing to try the mathematics strategies and approaches new to her but gave up when the content became too difficult for her. She wanted and felt she needed much guidance. If the guidance was not offered to her, she typically sat back and waited for someone in the team to offer her assistance. With the assistance, she once again attempted to do the mathematics. During these times, she would constantly remind the group that mathematics is not her thing but she is willing to try.

After our initial meetings of planning and doing some mathematics, we met again in October to reflect on mathematics in our classrooms. Tara reflected on how for the sake of time, she seldom uses discovery learning. She typically tells and shows her students how to do things. Tara talked about the mathematical practice of letting the kids discover (versus telling them the answer) is a struggle for her. From as early as August, she was cognizant of this issue. She constantly reminds herself to ask the students questions to help their thinking along versus jumping in and correcting them. She talked about time constraints.
She isn’t comfortable giving students the whole afternoon (which they don’t have) to experience tasks aimed at improving conceptual understanding. She is making an effort to improve at this. Tara talked about the fact that her students don’t have the language necessary to explain their thinking. She listens to them and helps them with constructing their thoughts using the academic language and has them repeat it.

**Focus on fourth grade teachers.** By the end of the session, Roxy and Heidi (and Tara by default since Tara uses Heidi’s lessons when teaching mathematics) revealed that they had already incorporated the eight mathematical practices into their Understanding by Design (UBD) lesson plans. They like the ideas associated with these practices. Both Roxy and Heidi seemed to be the most open to incorporating these practices in their lessons. Roxy shared, “they’re (students) not just solving it to solve it. They have to know they might encounter these kinds of problems in their lives” (Pre-implementation audio collaboration session).

Roxy showed a real desire to help all her students succeed and become better at mathematics. At the onset, she revealed that she has made reasoning a regular part of her class during the last two years. She continues to value it and knows what she wants at the end of the school year: she wants her students to be able to reason orally. In October, she was still guiding her kids and they were still writing their thinking as a script for conversation.

She has a desire to reach every student in her class. She was sharing that in a class of 30, she was finding this difficult to do. She had recently changed the way she managed her class during her mathematics time. She started incorporating what she termed as *math workshop* where her students would be
grouped according to ability so that she could assign different levels of work for the groups. The idea was to bring the high level group to an independent state so that she could work more closely with the other two groups. I was able to observe some of this dynamic during the implementation phase of the research.

At a larger level, Roxy seemed to be a visionary. She believed that collaboration among the different grade-levels is important to help students be on grade—level. She found that the variability in approaches to teaching at her school is causing too much variability in the classroom. Too many students are not “getting it” (Pre-implementation audio collaboration session). She is trying to change this at her school but is finding it difficult. “Yes, it’s important for them to know strategies but they also need to know the concept – how are they being taught from 1st through 4th?” (Pre-implementation audio collaboration session).

Mindy’s frustration with the Common Core standards being thrust upon us during this school year seemed to impede any attempts at trying new ideas in mathematics. At this session, she admitted, “I’m still trying to adjust what I know to fit the standards” (Pre-implementation audio collaboration session). The exchange between her and Heidi regarding the teaching of place-value revealed that she liked the idea of exploration but didn’t truly believe she could it. Mindy seemed to be the most hesitant among the four teachers.

Roxy and Mindy are not the same type of team as Heidi and Tara. Although both Roxy and Mindy teach 4th grade, they are from different schools. Also, Mindy joined the after school collaboration sessions with Roxy and I but Roxy did not join the sessions with Mindy and I. Mindy revealed that she benefitted from listening to the after school collaboration sessions between Roxy and me and from the video recordings that were left in our shared dropbox.
folder. In this respect, Mindy gained some confidence to implement the lessons from her participation with Roxy and me during Roxy’s implementation phase.

**First grade planning sessions.** The team of Heidi and Tara openly communicate with one another, freely ask questions, and don’t hesitate to ask for assistance from the other when necessary. Since they teach all subjects in 1st grade (with the exception of the Chamorro and Carolinian Language and Heritage Studies – CCLHS - class), they have come up with a system to help them plan their lessons to satisfy the requirements of their administration. In this system, Heidi is responsible for the lesson plans of the mathematics lessons. As such, Tara typically asks Heidi what they are doing the next week and they discuss the lesson before it is implemented. In this study, the planning was initially done by me. I had envisioned a curriculum unit that would fuse the western thoughts of mathematics with the ideas of our culture, the Chamorro culture. This lesson was brought to Heidi and Tara for their review and input. Our first meeting of review was in June 2012. Afterwards, I implemented their suggestions and brought it to other graduate students for their input. Then, in August, we met again for final revision. The final product in August was used during their implementation of the lesson in January 2014.

In June 2012, Heidi and Tara sat down and began talking about their upcoming school year and the new Common Core mandates thrust upon them by Central Office. I joined their discussion then led them to the focus of our meeting: reviewing and revising the curriculum unit on measurement. The session began with me introducing them to the eight mathematical practices of Common Core. Heidi was sure we wouldn’t be doing all the practices in our lessons but I assured her that we would. She was surprised. I reminded her that
the eight were not content standards but process standards. During this portion of the session, I did most of the talking with Heidi piping in every now and then. When we hit upon Practice 7, “Look for and Make use of Structure”, Heidi recalled a lesson she does with her students. She related how in first grade, skip counting is an integral part of their learning. When she feels that her students are confident skip counters, she asks, “What’s 3x3?” (Pre-implementation audio collaboration session). Her students are always stumped because they had never been exposed to multiplication before. She tells them that they can figure it out because they can skip count three, 3 times. Then, she says her students love multiplication and want her to give them more so that they could figure it out via skip counting.

As I was showing the lesson to the teachers, they would pipe in with some questions for clarification. When I used the word iterate in Day 2 of the lesson, the teachers stopped me to ask about the word. After some discussion, the teachers were relieved to know that they knew the concept but had never heard of the word before. I told them that they could choose to use the word in their implementation or if they felt the word was too difficult for the 1st grade students, they could opt to leave it out. Heidi took the lead and said she wanted to use it. Tara then chimed in and said that if it’s something the students need to know, then they should know what it’s called.

During the discussion of iteration, the teachers wanted to be sure they understood the word. As I was moving on to the next day’s lesson, Heidi stopped me with, “Go back. What’s iteration?” (Pre-implementation audio collaboration session). I proceeded to explain and then she interrupted with, “It’s a math word…” (Pre-implementation audio collaboration session). I told her
that it was and continued to illustrate when she said, “Oh, I never heard of it” (Pre-implementation audio collaboration session). I finished my brief demonstration of iterating when Tara asked, “What is it? It’s the ability to…” (Pre-implementation audio collaboration session). As she trailed off, I aided her in defining it. As I was defining the word, she would interject with questions for clarification and checked her understanding by asking if she could use Rainbow Cubes (1-cm cubes that are part of a MathLand curriculum) as objects to iterate. I told her she could but that I wanted her to use something that might be more readily available to the kids outside of school. We talked more about the value of being able to see everyday objects as measuring devices versus something that they could only find in school. Then Heidi thought of different ways she measured as a child. She recounted when marbles were her unit of measurement and how when she played “Mother May I?” the steps served as their unit of measurement.

As we continued to discuss the lesson, Heidi asked, “Do you want us to encourage them to find something a little bigger?” (Pre-implementation audio collaboration session). She was referring to the object that they would use to iterate to find their heights. She was afraid that if a student used a pinecone from the ironwood tree, they might find it takes too long. I suggested that they may want to let students use whatever they want and let them struggle with it. Then Heidi revealed that she let her students do that in the previous year when she tried the lesson without the story.

The year before, I had asked some teachers (Heidi and Tara were part of the original group) if they would like to be part of my study. I shared the lesson and the story with the teachers to entice them to say yes. At that time, I was still
awaiting the approval of my IRB and could not proceed with the study until such approval came. I knew that I would probably have to wait until the following school year to observe and send out my lessons. Heidi however liked the lesson ideas and with what she remembered, used the lesson with her students that year. I do not have data on these lessons except for whatever she revealed during our planning sessions. Because Heidi created her own version of this lesson in the previous year that most mimicked the part of the lesson when the students go out and measure their teammates, it gave Heidi a sense of confidence with the lesson. When asked, Tara indicated that she may have done a portion of the lesson too in the previous school year, but she couldn’t recall.

Heidi explained that she gave her students (during her piloting of the lesson the school year prior to my study) different non-standard unit options to choose from and some of her students opted for the bigger sizes and some of them loved the little ones. The students who chose the little ones needed more time to complete the task of measuring their heights. She recalled that some students never finished in the time allotted. She reflected that these students somewhat understood why they didn’t finish so she felt that not finishing was not a problem.

Our discussion veered into grouping. The teachers wanted to know how many students should be in the group. I gave them some suggestions but told them it was entirely up to them. They would know their students best and would be the best judge of what would work with those specific students. When we started to talk about the subsequent days and measuring with various objects inside their classroom, Heidi stopped me to find out what kind of prior knowledge I expected the students to have. I told her that I had no idea what
kind of prior knowledge they would have and that the level of precision of measuring would depend on what the student’s prior knowledge is. I told them that I left the idea of precision in their hands because they would know if their students could be precise about the fractional units or if rounding would be acceptable. Heidi then asked about the quantity of the items that would be used to iterate. I told them they could decide what they felt was appropriate.

At the end of the unit discussion, we talked about when they would implement the lesson. The teachers talked about September being too early because school would have just started. I suggested October and in the end, they agreed to it but they were hesitant. They felt October might be too early in the year too. November was dismissed because Heidi was pregnant and was scheduled to give birth then. December was not an option because the holiday season was deemed to be too busy to include observations. I originally wanted to have the observations completed before 2013 but I informed the ladies that if it turned out that October would have been too soon, it would be okay to change the date.

The teachers then asked me about the video. I reminded them that the focus would be on them because I wanted to see whether the collaboration helped them with their teaching.

Heidi thought about the trial she had done the previous school year and recalled that some of her students traced the outline of their bodies to find their height. She wanted to know if it would be okay, if she sees this happening again, to take out a long piece of string, place it flush against their measurement and then hold it taut against the student when the student stands to illustrate how
the measurement that hugs the body does not equal the height of the student. I told her it was a great idea if she encountered the same issue again.

Tara then asked about students who would not want to lie on the ground. Heidi interjected saying her students would not have issue with that. I also mentioned that when Roxy did it with her students the year before, as a pilot, she hadn’t suggested they lie on the ground, they decided to do that on their own. I told her that if she thinks it would be a problem, she could suggest students bring a towel.

When August rolled in, I brought a revised unit plan and explained to the teachers that the revision was to allow for more depth of the concepts. As a result, the last day of the original plan in June was omitted from the 5-day plan. The appendix shows the August plan with revisions made as the plan was being implemented in January 2013.

As I explained that the unit as originally planned lacked depth, Tara piped in sharing that she too was concerned about time. I proceeded to share the revised plan. Days 1 and 2 had not changed. Day 3 began the same way but it allowed for students to practice the concept of iterating from different perspectives. Instead of only counting how many units long an object is, it also allowed for students to draw objects of various unit lengths, and then look for objects that they estimate to be a specified length. Consequently, Day 3 became Day 3 and Day 4. Heidi and Tara asked several questions to clarify some points on days 3 and 4 and then their conversation steered into the lesson plan itself. We were discussing the types of questions they could anticipate to ask students during the lesson and a question was brought up that was not in the lesson. This led the conversation to the Essential Questions in the lesson plan. They then
proceeded to share how some parts of the lesson plan were more for administration rather than for their use. They revealed the types of lesson plans they would prefer to use.

The lesson plan conversation lead to Tara asking if anyone has seen a curriculum map for the Common Core math at PSS. This question was prompted because Common Core was new to the system at this time and I wanted to let the teachers know that these lessons were Common Core ready. I asked the teachers if they had seen the Common Core standards. They said they had. This led us to revisiting the importance of the process (the Eight Mathematical Practices) and the intent of the Common Core to explore mathematical practices in more depth. The teachers hoped that this level of depth would help more students pass exit tests that PSS is discussing for 3rd grade and 6th grade students.

I then directed the teachers to the part of the lesson plan that talked about assessment. I told them we would talk about Heidi’s assessment in more depth a little later. The teachers asked about the old day 5. I told them we would not be doing the lesson. I told them they could do the lesson if they wanted to but I wouldn’t observe it.

I directed their attention to the information after the lesson plan. The information I needed from them: their observations, their reflections, their anecdotal remarks, in addition to their video and audio recordings. The teachers asked me some questions to clarify some of what was expected of them. Then Tara asked Heidi if her math time is the same as last school year’s. Heidi said yes. I noted that since both would have the same math time, I would only be able to be in one of their rooms but I would expect the other to record herself as she teaches.
Due to technical difficulties with the recording devices both the video and the Word document I used on the iPad, I was not able to record the full 5 days of implementation from any one teacher. As a result, I have video or audio recordings of days 1-3 of Heidi and video of days 3-5 of Tara. Any observations of Tara or Heidi on the days for which I don’t have the recordings are the results pulled from the audio recording of the collaboration session that followed each lesson. I reported the cases of their implementation and the collaboration session that followed after school that day. I successfully attained 5 full days of recording the collaboration sessions that followed each lesson.

**First grade implementation of unit: Heidi.** Students began with a poor understanding of measurement as seen in Heidi’s case of her day 1 questions when her students indicated that their height measure was equal to their age, but in feet.

After checking her students’ prior knowledge, Heidi previewed the story she was going to read by showing the cover page and the title. Students then proceeded to listen and interact with the story by responding to the questions Heidi asked as she read the story (Miura, 2009).

The story is about a boy, Jose, who needs to find his height because he needs to get a suit sewn for a school dance. It is set in the Marianas post World War II. The story incorporates the Chamorro culture and language as Jose ventures out into the village to find his height. Throughout the story, it is evident that the narrator is on an island where the culture and the language are not primarily western or English. As Heidi read the story, she stopped several times to explain some of the Chamorro and cultural practices used.
Her first cultural pit stop was the title page. Many of the students read the title as Joe’s Many Heights. She told them that they were correct but that Joe was the English version of Jose and that the story uses Jose instead of Joe. When she came across the setting, she explained World War II as a war that was here a long time ago, before she was born and before I was born. As she encountered the various characters, she explained the significance of how Jose called them. The first character (other than Jose) that needed some explanation was Tan Marakita. She explained that when you hear the word Tan in Chamorro, it means something like a great aunt. She proceeded to explain that the word Tan is usually associated with someone a lot older, “don’t expect to see your classmate, you’ll see someone older” (Day 1 video implementation). As Jose set out to find his height, he encountered his nino. The class knew that nino and nina are godparents. She explained that nina is for the godmother. When Jose met his nino, he greeted him with nyot. Heidi asked the class if they knew what nyot meant. Most said yes. She explained that in Saipan, some people say nyot when bringing their forehead to the elder’s hand and others bring their nose to their elder’s hand. “Even in the Filipino custom, you do the amen right?” (Day 1 video implementation). The amen she is referring to here is one of the verbs used to tell someone to go and say nyot to an elder or to go and pay your respects to an elder. As the story progressed, Jose ran into another elder, Tun Juan (Heidi explained that Tun is the male version of Tan) who presented him with an explanation of his height that was contrary to his nino’s description. The story explained that despite his confusion, Jose couldn’t disagree or question his uncle. Heidi stated, “…in the Chamorro custom, if the older people tell you to do something, or listen to them, you have to out of respect. Even though you’re confused, you still listen
to them. You have to let them finish everything that they have to say” (Day 1 video implementation).

The story problem, events, and resolution revolved around the mathematics of measurement. As the problem is introduced in the story, Heidi stopped and asked, “When someone says you have to find your height, what are they saying?” (Day 1 video implementation). The students responded with finding “how tall you are” (Day 1 video implementation). Some students said how high you are. Heidi relayed that high was not wrong but that usually the word tall is used when talking about height. She gestured to show which direction height was by using her right hand and placing it just above her head and extending it upwards. Throughout the story, Heidi constantly asked her students what Jose’s dilemma was and asked them to define height.

When Jose visits his first helper, his nino, the students hear that his nino will measure Jose using coconuts. Laughter erupts in the classroom. Heidi notices this and asks, “You ever use a coconut to find your height? No?” (Day 1 video implementation). She then asks the students how they think Jose’s nino will use coconuts to find Jose’s height. Two ideas that were recorded include putting the coconuts on his head and lying on the floor. Heidi asked for clarification, “Who will lie on the floor?” (Day 1 video implementation). The students chorused Jose. Heidi then asked them to clarify. The students said Jose would lie on the floor and his nino would measure Jose using the coconuts. Heidi lauded their ideas and proceeded to read.

When Heidi finished reading about Jose’s second height measurement, she asked her students why Jose looked confuse in the story. A student stated that it was because Jose has been presented with 2 different heights: one with
coconuts and one with bull horns. Jose’s height is 3 ½ bull horns tall. Most of her students respond that he is 3 bull horns tall. Finally, she told the students he is three and a half bull horns tall and asked them if anyone knew what a half looked like. Various yes and no responses emerged from the group. One student volunteered, “You take the whole bull horn and then you cut in the middle” (Day 1 video implementation). Heidi repeated the student’s words and then grabbed a rectangular piece of paper and demonstrated half for them. She started by saying that the piece of paper represented the bull horn. Then she folded the paper in half and said that the folded piece was half. She unfolded the piece of paper and repeated that it was the whole bull horn and then tore the sheet in half to show half a bull horn. She then took 3 identical rectangular pieces of paper (identical to the one she tore in half) and had the students count each bull horn with her, including the half. After summarizing the events of the story so far by saying that Jose was 6 coconuts tall and 3 ½ bull horns tall, she asked the students how that can be possible. A student responded with, “He’s 10, I mean 9” (Day 1 video implementation). Heidi was confused and asked the student to explain. The student said, “Because that’s his own height” (Day 1 video implementation). Heidi realized how the student came up with 9 and asked, “If you put the coconuts and bull horns together, is that how tall he is?” (Day 1 video implementation). The student insisted that measurement worked that way. Heidi let it go and continued to read.

After his meeting with the last elder, Jose was presented with yet another height measurement. Before Heidi read Jose’s height in seashells, she asked, “Do you think the number is going to go up or down?” (Day 1 video implementation). The students answered up in unison. Then Heidi asked why? At this point, some
students changed their answer to down and one student reasoned, “Up because the seashells are smaller” (Day 1 video implementation). Heidi asked them to clarify by asking them what the seashells were smaller than. The students answered her with coconuts and bull horns. She then said, “Before we end the story, I’m going to ask you which height you think is the correct height. So be thinking about that” (Day 1 video implementation).

Before Jose visited his grandmother (Nana) who clarifies his dilemma, Heidi asked the students to vote for which measurement they thought was correct. As she asked for a show of hands, one student yelled out that they are all wrong. Heidi then included “all wrong” and “all right” as part of the ballot. She informed students that they could change their minds because the last 2 ballot items were last minute additions. At the end of the polling, Heidi noted that many students voted that 60 seashells was the correct height measurement.

After reading about Jose’s visit with Nana, she asked if each elder was correct. After each elder’s name, all the students responded with yes. Heidi summarized their responses by saying that all the elders were correct. One student said, “'Cause he makes them up together” (Day 1 video implementation). Heidi asked for clarification. The student couldn’t respond at that moment. Heidi continued to read. One of the pages of the story lined up Jose against each measurement showing how his height hadn’t changed but that only unit changed. Heidi asked the students if they could see why all the measurements were the same. They all answered yes. However, that one student that insisted on putting all the measurements together continued to do so and stated that Jose was 69 feet tall. Heidi then asked, “If I put the bull horns and the seashells on top of the coconuts, is that how tall he is?” (Day 1 video implementation). A mixture
of yes’s and no’s could be heard. Heidi explained, “No. So you don’t put them
together right? You don’t put them together. That means a height of 6 coconuts is
equal to…” (Day 1 video implementation). The students were able to answer this
line of reasoning with ease however they were still unable to connect their
assertion that the heights were equal with the height of Jose. Some students still
insisted on putting all the numeric values together to come up with a total height.
Heidi left the students with their confusion knowing that they would be tackling
this height problem again the following day.

First grade implementation of unit: Tara. From the collaboration sessions,
Tara revealed the same type of responses in her class when she checked for her
students’ prior knowledge. One of Tara’s students said his height was a size 12
and another student was a size 8. When Tara asked the size 8 student how he
knew, he told her that he went to the doctor and stepped on the thing (Day 1
audio after school collaboration session).

“How do you know” was not a question on the lesson plan but a good
question that was later added to the lesson. Other questions that were added to
the lesson plan as a result of this first day of collaboration were: 1) Are there
other kinds of measurements? And 2) Where do you see measurement? Tara
used these questions in her class and they yielded insights into what students
know. Tara had asked her students where they’ve seen measurement. She was
pleasantly surprised when her student HN responded by relating that she had
seen people at the store put food onto a scale and a certain number of pounds
would appear. Heidi shared that it made sense HN would share something like
that since her mom works at a store and HN probably spends a lot of time at the
store with her. This led to discussion about the importance of context in the
classroom. Tara had commented that HN was the most vocal student during the question and answer session prior to the reading. We had discussed that real-life experience helps students connect to their classroom experiences.

Tara read the story without making any cultural pit-stops like Heidi. She felt that there was no need to elaborate during the cultural instances in the story because the students should already be aware of the culture since they lived in Saipan.

**First grade implementation of unit: Collaboration Session 1.** As we started the day 1 collaboration session, I quickly noticed that the teachers were very concerned about being true to the lesson. Whenever they deviated from the lesson, they asked me if it was okay or if they could make up not asking a certain question or doing a certain task the next day. Typically, my response was that I expected the lesson to morph into something a little different for each teacher because of the dynamic of their classes and each teacher’s personality and teaching style. These cases have revealed instances of the changing nature of curriculum.

The biggest concern that our session unfurled was the length of the story. Heidi revealed that she and Tara talked about the number of questions that they felt they had to ask to help the students understand the story. This alerted me to the nature of collaboration between these two teachers. It was apparent that they collaborated on a regular basis, informally or formally. These teachers were accustomed to popping into one another’s classroom and chatting about a lesson. This, in addition to my relationship with these teachers, explained the willingness of these participants in my study. It served as a bias in favor of my study. If I had done this with teachers who were assigned to me or were teachers
who preferred to work alone, the outcome of my sessions and possibly the lessons would have been different.

Tara interjected and steered the conversation back to the beginning of the lesson when she started with asking her students about what they know about measurement. This discussion led to our understanding that the students in her class understood some aspects of measurement but that both sets of students knew very little about height. The teachers knew that they were starting with a blank slate with some students. Throughout the lessons, it became clear that the students with the preconceived notions of feet, inches, and rulers were the ones who were resistant to using the non-standard units. Their resistance came in the form of them insisting the need to use a ruler to correctly measure or using inches or feet instead of the non-standard unit when reciting the measure of the object. When students insisted on using a ruler to measure, it revealed that those students associated rulers with measurement but didn’t understand the ideas behind measuring length or height. If they had better conceptual understanding of measuring length or height, they would have been able to measure with non-standard units too.

Our discussion about the dialogue that occurred during the pre-reading session led us to add more questions to our lesson plan and helped us understand the student assumptions about measuring length or height. During this discussion, Heidi shared that she was surprised that students claimed to be 8 feet or 9 feet tall because earlier in the year, Heidi had shared a news story about a giant squid that was caught. The squid was reported to be 9 feet in length. She had discussed this story with her students and included an illustration of what 9 feet looks like.
When we moved to discussing the story, the notion that the story was too long came up again. The teachers wanted me to make changes to the story to make it more appropriate for 1st grade. Heidi suggested I get rid of the parts of the story that explained the reasons for the characters using certain units. I didn’t agree with her. I reasoned that the explanation gave the students context for the use of the units. When we started talking about HN and her ideas of measurement, they were able to see the strength context can bring to ideas. As the teachers were talking about words being too difficult, the story is too long, and some of the illustrations showing emotions that they felt didn’t match the story, I listened. I agreed with most of their concerns. I told them that I had written the story with an older child in mind. However, I felt that if the story was broken up into two days, it might be more manageable for the students. Tara recalled that at our earlier collaboration sessions, I had asked them if they thought the story was doable for 1st grade. At the time, Tara said she wholeheartedly believed it was but after reading the story to her kids, she realized that it was too difficult because of some of the language used in the story. By the end of our session together, we all felt that splitting the story into two days may be the best alternative for the unit. The teachers felt that it was okay to expose the students to some of the challenging vocabulary but that it would require more explanation on their part therefore necessitating the 2-day reading.

After we had spoken about the story at length, we began to talk about day 2: the day when students go outside and use non-standard units to measure their heights. Tara was concerned about several things. She wondered about the feasibility of having both classes out at the same time in the same general area to do their own measurements. She was worried that there would not be enough
resources for the planned 16 groups of three students. I mentioned that if there weren’t enough resources, the students would be forced into iterating one or two units instead of trying to find many of the same unit to line up against one of their peers. This turned out to be a non-issue as resources were plentiful and the groups used different units to iterate. Most groups lined the same objects (although different in size) along their peer to measure. Heidi was primarily concerned that this would occur because the story never showed Jose iterating. It only showed his measurement after his elder had measured him and it displayed the final result with the number of units needed for his height perfectly matching one another. We knew that it would be difficult to find identical coconuts, leaves, or sticks. Heidi feared the students would ignore the sizes of the units and line them up to measure their teammate’s height. That is precisely what had happened. I suggested she need not worry about them measuring correctly for this first hands-on experience and use it and the photos as learning opportunities for the next day. Tara was concerned that she would not be able to video tape, take still photos, and roam and help students. I told her that she could forego the videotaping outside since both classes will be outside and Heidi’s aide could videotape both classes. She agreed. Unfortunately, technical difficulties arose with the video camera when we went outside so no taping of the outdoor activity occurred.

As our discussion continued, I realized that both teachers were very concerned about students making mistakes and how they should handle it. I presented them with a couple of ways to use mistakes as learning opportunities: 1) Anchor back to the story and ask the students if they can recall how Jose was measured, and 2) Let the students make the mistakes, especially if a good
conversation about the way they are measuring occurs and bring it back to the classroom the next day. I warned them that because of the size of their classes and the amount of time allotted for the activity, they may not be able to visit with their eight groups. They may find they have to help one or two groups who have no idea of how to proceed.

As discussion about day 2 continued, I asked the teachers if they had introduced the word iterate to their classes yet. They had mentioned in earlier sessions that it was important to them to have the students know and use the word. Neither of them had used it yet. Heidi didn’t want to introduce the word since it wasn’t used in the story. I suggested that if they wanted to introduce it earlier, it could be used when the teachers tell their students that they will be going outside the next day to describe what they’ll be doing. Heidi announced that she would introduce the word on day 2.

The last 15 minutes of discussion centered about the logistics of the groups. Heidi and Tara discussed which student would Tara send over to Heidi’s class for both teachers to have a complete set of eight groups of three. This deliberation led into a discussion of group composition. They decided that each group must have a proficient writer. Tara insisted each group have a responsible student to help keep the group focused. Heidi shared that she would assign a recorder, a measurer, and a student to be measured. Heidi then asked me if I had a document for the students to record their findings. I told her that I did not have one. This prompted Heidi to volunteer to create something for their students to use. This document was utilized in Heidi’s class the next day. Her document included the names and roles of each student.
First grade implementation of unit: Heidi. Day 2 began with Heidi and Tara remaining in their separate classes for about 30 minutes then both classes met outside to begin measuring themselves.

In Heidi’s classroom, she began by asking the students why Jose had so many heights. Heidi tried to get the students to see that the size of the units determines the number of units needed to measure the height. She asked them questions to help them compare the unit sizes against each other. She repeatedly asked who had the correct measurement. The students were still divided with their responses. Most students still believed one measurement to be more appropriate than another. Heidi let it go and proceeded to introduce the word iterate to the class.

She began by showing the class the picture from the story where Jose was standing and the 3 different units (coconuts, bull horns, and seashells) were placed next to Jose indicating his different heights. She reviewed the three different units and then focused on the coconut. She asked the class to tell her something about the coconut. One student answered 6 while others gave answers relating to its size. Heidi acknowledged their responses and framed her question a little differently: she told the students that the answer she’s looking for can also be said about the shells and the bull horns. Again, an answer about size emerged. Finally, Heidi responded by comparing the sizes of the units but asked again, “What can you tell me about the coconuts? AO? Are they all the same size?” AO answered yes. She asked the class to carefully examine the projected illustration to see if they agreed with AO. Some students agreed and some disagreed with AO. Heidi asked the students to gesture with a raised hand if they thought all the coconuts were the same size and to place their hands on
their heads if they thought they were different sized. She did this several times. She then stated that she agreed with the students who said that the coconuts were the same size. She then checked for understanding by asking them to repeat what it meant to have a raised hand. Some students understood the gesture while others thought it meant to indicate that they thought the coconuts are big. Heidi then asked if the students could say the seashells were all the same size. Some students said yes while others said no. Heidi revisited the meaning behind the gestures. Again, she stated that she agreed with the students that had their hand raised. She then directed their attention to the bullhorns, asked them to look at the 3 bull horns and reminded them what each gesture meant. She then asked why some of them thought they were different sized. Student M answered that the bottom one was small (he was referring to the half-sized bull horn). Heidi repeated what he said and followed with a question that directed him to look only at the 3 whole bull horns. Student M said that they were the same. Heidi then asked the class why the bottom one was different. The students were able to say that it was half a bull horn.

At this point, Heidi introduced iterate. She wrote it on the Elmo® and the students worked on trying to pronounce it. Heidi said the word for them and had them repeat after her. She explained that when the characters measured Jose’s height, they iterated.

After some comprehension checks on the word iterate, Heidi asked the students if they think Tun Goru (Jose’s nino) used different coconuts or the same coconut. Some students said different and some said same. To clarify, Heidi asked students to raise a hand if they thought Tun Goru was using the same coconut and put their hands on their head if they thought Tun Goru was using
different coconuts. Most students had their hands on their heads. Two students in the video shot had their hand up (one boy and one girl).

Heidi then proceeded to see what the students thought about Tun Juan’s bull horns – same bull horn or different bull horns? This time, six students had their hand up. The girl from the original two that had their hands up put her hands on her head for Tun Juan’s bull horns while the boy kept his hand up. Then Heidi asked about Tan Gora and her seashells – same or different? Thirteen students had their hand up and the two students who voted for the same coconut earlier were part of this 13. Finally, Heidi asked about Tan Magarita [sic] and her use of the stick – same stick or different stick? Nine students had their hand up, including the two from the coconut poll. It is important to note that these numbers are based on the students who were within the frame of the video camera. Students from outside the frame were not accounted.

Heidi repeated that when these four characters measured Jose’s height, they had to iterate, “that means they had to repeat the unit” (Day 2 video implementation). She instructed the students to iterate the same unit when they go out. She asked, “That means if you decide, when you go outside, to use a rock, are you going to collect 10 rocks or just 1 rock?” (Day 2 video implementation). The students enthusiastically answered one. She explained that they would collect 1 rock and that they would use that same rock to measure their classmate’s height. She informed them that they would have to decide how to do that. She told them that she would be roaming and asking questions. She repeated that they would be iterating outside and asked them to recall the definition of iterate. Immediately following the review, she showed them their task sheet. She told the class that she had grouped them in teams of three. Each
team member would have a job assigned by her: the measurer, the one being measured, and the recorder. She explained each part of the task sheet as she read it to them. She informed them that before they could go out, they had to meet with their teammates and create a plan for measuring. She informed the class that two groups would share their plans with the class before venturing out. She showed the class where the teams were announced and included one boy from Tara’s class into her group of two. The first task in creating the plan would be to indicate the unit the group would like to use to measure. She told them that when they go out, they will look for their desired unit of measurement. If the team cannot find their unit of measurement, they should feel free to change their minds but they must do so quickly. The next part of their plan was to indicate how the student will be measured: standing or lying down. Heidi proceeded to explain how the sheet will indicate their jobs. She showed one sheet and said, “AO will be working with CH who will be measuring AO. And SH will be doing the recording” (Day 2 video implementation). She emphasized that the group must measure the student twice “to see if you get the same number” (Day 2 video implementation). She noted that if their numbers are different they have to measure again. She then told the students that if time permitted, they could measure another student in their team but that if they ran out of time, it would be okay to measure the one student pre-assigned. She finally called out each group to obtain their planning sheet and allowed the groups to gather and begin discussing their plans. After about a minute, Heidi roamed and used the questions on their task sheet to check their plan. At one group, she noticed that they wanted to use a tree to iterate. She asked, “Can you move a tree?” (Day 2 video implementation). The student said that they would use a rock because the
tree cannot move. The same student said that they were going to count JE’s body. Heidi asked the student to clarify. The student response could not be heard but Heidi replied that she is curious to see how their plan would work when they go outside. Heidi asked if JE would be standing up as he was being measured. His teammate answered yes but JE said he would lie down. She pointed out that they disagreed and asked the teammate to write the plan they agree on.

After about three more minutes, Heidi asked the class to pause and assembled the students into a whole group. She asked AO to share first. AO reported that they would use a leaf from the ground. He said his group would use just one leaf but then changed his mind and said that they would use lots of leaves to measure MN standing up. At this point, Heidi reminded the students that if their plans didn’t work out, they should feel free to change it but to keep in mind that they have a limited time outside and that if they kept changing their plan, they would not have enough time to finish the task.

The next group who shared relayed that they would be using sticks to measure their teammate standing up. After their sharing, Heidi reminded the students that they will continue to be filmed and that she would be roaming as they measured in their groups.

**First grade implementation of unit: Heidi and Tara.** Once outside, the students joined Tara’s class and began measuring. Both Tara and Heidi travelled and spoke to various groups as they measured each other. Various objects such as sticks, leaves, and coconuts were used as measuring units. Some students were lying on the ground while others stood. The group that Heidi was curious about stood by a tree to mark the height of JN. One group from Tara’s class used
one tall ironwood stick and marked the boy’s height against the stick. After about 15 minutes of measuring, the students returned to their classrooms.

**First grade implementation of unit: Tara.** Although we did not capture video or audio recordings in Tara’s class, Tara wrote a detailed reflection of her day with the students prior to meeting for our day 2 collaboration session. She noted that this was the second time in the school year that she had her students work outside. Earlier in the school year, she had her class go out for a science activity. Because this was only the second time her class of first grade students had gone out to explore, she found that many of them were not on task. They listened to her when she stood by them but once she left, many felt free to run around and do other things. The learning she witnessed however, made her believe that if her students had more practice working outside, they would become more productive in that setting. To help teach her students to work better outside, she recommended that she videotapes her students as they are in that setting, bring the class back together and watch the video to help illustrate the types of behaviors that are desired and those that are an unacceptable.

With the lesson plan in hand and the previous day’s collaboration session on her mind, Tara’s time spent with her groups that were on task was productive. She noted her visits with three different groups. These three groups used coconuts as their unit of measure. All students were instructed to leave evidence of their measurements for discussion with Tara when she visited. At RD’s group, their measurement of JL was laid out. Tara rearranged the coconuts and removed some creating spaces between the coconuts and making JL’s height less than what was recorded. Tara asked RD if the new measurement of JL worked as well as the one they had done. RD responded in the affirmative. Tara then asked, “But
is it the same number of coconuts?” (Day 2 reflections). He acknowledged that the numbers were different. She asked him if it was okay to measure JL both ways. RD and the other group members didn’t know how to respond to the question. At a different group, Tara exchanged a big coconut with a smaller one creating a space between the last coconut and the student’s feet. TI saw the space created and retrieved another smaller coconut to fill the space and then counted the number of units for the student’s height. Finally, at EL’s group, Tara changed the orientation of the coconuts creating some horizontal coconuts and some vertical coconuts. Tara asked EL and his group if her way of measuring and their way of measuring were correct. They were able to tell her, “No because they all have to be facing the same way” (Day 2 reflections).

First grade implementation of unit: Collaboration Session 2. Heidi revealed during our day 2 collaboration session that she was not satisfied with the activity. She felt that the students made too many mistakes. Her concern was primarily with the students not iterating correctly. They made mistakes with varying the size of the unit, the orientation of the unit, and the spacing of the units (gaps and overlaps). She was not satisfied with the outcome. Consequently, when they returned to their class, she had a reflection session with them asking them to share their concerns and then she shared her concerns. Her students were primarily concerned about the heat and their teammates not cooperating. They discussed ways to remediate their issues. Then Heidi shared her concerns which dealt with the way they were measuring. She engaged the students in a guided question and demonstration session to see if they could identify their errors. When she tried to ask guiding questions, the students were not able to see their errors. Then she had her son (he sometimes assists her in her room) get
some sticks and coconuts from outside for her to demonstrate the way the
students were measuring. She used three different sized sticks to measure a
student’s height. After the demonstration, students were still not able to identify
any errors. Heidi then referred to the story of Jose and asked them to think about
what would have happened to Jose’s clothing if he measured the way the
students had (and demonstrated this again) and Tan Marakita measured using
this as her stick. The students understood that the clothing would come out the
wrong size. They had a hard time explaining why. Heidi finally decided to tell
them that the same unit had to be used when iterating otherwise problems such
as wrong clothing sizes might occur. She then proceeded to explain overlaps and
sent them outside for a second try at measuring their heights. She felt that they
performed much better, although not perfectly, the second time.

Tara revealed that the lesson was chaotic for her. Her concerns were
primarily with the management of the class. Her solution would look like Heidi’s
second session and reflection session. Heidi would include in the reflection
session a time for the students to watch their behavior on a video and discuss the
behaviors illustrated in the video.

Both teachers believed that the lesson was a good one and with the
modifications suggested to include time for reflection and going out for round 2,
it would be better. Tara reflected that the measuring activity represented “real
hands on learning that took place amongst the chaos” (Day 2 reflections).

After we had discussed the lesson, we talked about day 3. Tara decided to
do what Heidi had done for her second session on the morning of day 3 then she
would proceed as planned with day 3 at her designated mathematics time. The
teachers felt comfortable with the next day’s lesson and not much time was spent discussing it.

Through Tara’s self-reflection, I learned that the collaboration sessions were useful for her. She revealed that she and Heidi regularly collaborated with a few words during recess, lunch, or after school. She revealed that Heidi plans the math and science lessons while she handles the language arts and social studies lessons. Tara finds collaboration a great way for her to be exposed to different ways of looking at the lesson and different ways of executing the lesson. She finds the collaboration sessions for these units to especially helpful. It helps her “get ideas on what to do next time to improve (her) teaching and (her) students’ learning” (Day 2 reflections).

**First grade implementation of unit: Heidi.** The plan for Day 3 called for students to measure objects in their classroom and to identify an object that is a set number of units long. Heidi and Tara started their lessons differently. Heidi started by reviewing the idea of iteration with her students. Once Heidi was satisfied her students understood how to iterate, she showed some pictures from the previous day. Unlike Tara, Heidi showed a few pictures.

Heidi asked the students to recall the units they had used yesterday. She then directed the students to look at the picture she had printed. She asked the students to identify the unit used in the photo. They recognized the units as leaves. She asked, “Do you think they were iterating with the same unit?” (Day 3 video implementation). Some students said yes and some said no. Heidi asked students to explain. A student answered that since the leaves were not the same (sized), the student didn’t iterate correctly. Heidi repeated this same question several times each time getting a different student to say that the leaves were not
the same. Then MK said, “There’s big space” (Day 3 video implementation). Heidi repeated what MK stated and asked the students if it’s okay to iterate with spaces between the units. The students said that it was not okay. After having the students repeat that spaces between units is not okay, she then asked the students to look at the direction of the leaves. She pointed out that some leaves were oriented differently. She asked the students if this was acceptable when iterating. The students said it was unacceptable. Heidi then summarized their findings and then drew leaves overlapping to measure the student.

She asked if her drawing showed the correct process of iteration. Some students said yes and some said no. MJ said it was incorrect because “it’s too close” (Day 3 video implementation). Several students described the leaves as being on top of another. After drawing different situations where an error in iterating was the focus and having her students identify the error, Heidi drew a correct sample of iteration and asked if there was “a lot of space in between”, if any of the units were “touching each other or on top of each other”, or if they were “going in different directions” (Day 3 video implementation). All questions were answered with a no.
Heidi showed another picture of student Z measuring JV. She shared that she remembered Z’s measurement technique from the previous day. Heidi held up a pencil in her hand told the class to pretend that it was the stick that Z was using to measure. She began iterating and showed Z to be 3 sticks long. She then asked the class if she had iterated correctly. Student J said, “No because they are making big space” (Day 3 video implementation). Heidi stated that it was possible. She proceeded to explain that when iterating, the students may want to start from the bottom for the sake of ease but that they could start from the top, if
they preferred. She showed them that when they iterate with the same unit, they could mark where their unit ended with their finger so that they may know where to begin with the next unit. She told Z that he would have had a better idea of how tall JV was if he had a system for marking his end and start points for each unit.

After trying to remediate the issue of overlap or space between units, Heidi told the students that each team would receive identical baggies with 5 objects in it: a marker, a clothespin, a popsicle stick, a paintbrush, and a cork. The groups would also receive the same unit of measure to measure the objects in their baggie. She informed the students that she would roam and visit with each group to check if they can iterate correctly. She relayed that if she was comfortable that their group was iterating correctly, she would give them a piece of paper for the next task: trace the objects from the bag and measure the length of the traced object as directed by the teacher. She demonstrated repeated the directions and demonstrated the task.

Heidi drew some paperclips lined up to indicate the length of an object. She asked the students to tell her how to say the length of the object. Before students could answer they had issue with her drawing because her units weren’t drawn the same. She apologized and asked them if they could pretend it was drawn correctly so that they could indicate the length of the object. She began to tell the students that the object is five and trailed off. Student L added, “and 1” (Day 3 video implementation). Heidi then said, “Five… paperclips long. You need to add the unit” (Day 3 video implementation).

Heidi indicated that in the previous lessons, they were talking about how tall something is. She asked the class what word would be used to describe how
long something is. Student A said length. Heidi repeated A’s response and asked the class to repeat after her. She then asked if anyone knew what length meant. Since no one was responding she reminded them that height means how tall you are. Then student J interjected with, “How long you are!” (Day 3 video implementation). Heidi asked her class to stand up and proceeded to get them into their groups, distributed their baggies, their unit of measurement and instructed them to begin measuring. As she roamed, she reminded students to watch as their teammates measured. Some of the questions Heidi asked as she roamed include: 1) Do you agree with the way she iterated? 2) Can you watch her again? 3) Do you agree that the object is x paperclips long? 4) Did you notice that there were spaces between the paperclips? 5) Were there spaces between the paperclips? 6) What did she make a big space with? Heidi found out that many students were creating space between paperclips when they used their fingers to mark the end of the previous paperclip. She reminded the students that made finger spaces between paperclips that the space between the units must be “the smallest possible” (Day 3 video implementation). She reminded the students that they have two paperclips to use if they’d like. Another issue that had to be remediated with some students was the use of the language. Although we witnessed the students measuring with the paperclips, they insisted that the unit of measure was inches. Heidi had to help those students see that they weren’t using inches but paperclips.

First grade implementation of unit: Tara. Tara started with the photos from the previous day as indicated in the lesson plan. The purpose of using the pictures was to assess student understanding of iteration through identifying errors in measurement from the day before. Tara used over 10 minutes of her
class time to review the definition of iterate via the photographs. Through this activity, the students were able to recall that units iterated correctly had to be the same size, had to be oriented the same way, and could not have space between the units. Students associated the units not being crooked with orientation. In this class, a couple groups didn’t start at the feet or head of the student being measured or iterated more units than the height of the person on the ground. Each time that occurred, the students were able to recognize those errors. Tara brought the students back to the story of Jose and asked the students why Jose needed his height. They remembered he needed it for clothes. Tara asked the students, “If Tan Maratita [sic] makes JH’s clothes and JH says he’s 10 coconuts tall, what’s going to happen?” (Day 3 video implementation). The students responded with saying that Jose’s clothing would be a little big (this in reference to a photo of JH being measured with 10 coconuts that extended past his height). Through her self-reflection of day 3, Tara felt that she probably didn’t need to spend so much time with the photos.

When Tara showed the photos, she had her students on the carpet. The carpet was Tara’s step away from a whole class arrangement when all the students are spread out on the floor at their assigned desks. It was her method for helping the kids focus. Because they were on the carpet, they were closer to the projection of the photos. On two occasions, one girl felt the necessity to go up to the projected photo and point out the spaces between the units. About halfway through the photo activity, Tara introduced the word *accurate* and began using it regularly for the remainder of the activity.

After the photo session, the plan for day 3 called for students measuring objects in their classroom and having students identify an object that is a set
number of units long. Tara went directly into this part of the lesson while Heidi decided to talk about an issue she noticed her students were experiencing with measuring: overlap and/or space between units.

In Tara’s class, immediately following the photo session, “Today, you will iterate some more… we’ll measure some things that are inside the classroom. We won’t be iterating with coconuts” (Day 3 video implementation). The students asked if they would use sticks or blocks. Tara told them they would be using paperclips. She instructed them to draw their objects on their drawing sheet and measure the objects using paperclips. “I will make it harder today. I’m going to try and see how it works. I will only give you two paperclips…” (Day 3 video implementation). During the directions, one student chimed in that he knew how to measure while another was incredulous that they would be using paperclips. She let them know that she would be roaming and asking them questions like how long their object is. She continued to tell them that after they measure their object, they were to draw it on the sheet of paper and then measure it again to verify the measurement. She told them that they may be measuring crayons, pencils, and other objects that she couldn’t recall at the moment.

After giving the students about 8 minutes to iterate with the two paperclips, she realized that it was too difficult for her class. She announced that she would give the groups more paperclips to help them measure. Groups with just the two paperclips couldn’t figure out how to iterate with just two paperclips. They asked their teacher if they could unfurl their paperclips to lengthen it. Tara told them that they couldn’t do that. After another 3 minutes, Tara called the class back to the carpet for some remediation.
At the carpet, Tara told her class that she didn’t have enough paperclips so she decided to start with just 2 paperclips. A student exclaimed, “It’s hard” (Day 3 video implementation). Another student claimed that he needed a ruler. Tara reminded them that they are measuring with paperclips, not rulers. She taped her marker to the whiteboard and asked the class how she could measure it using only 3 paperclips. She revisited that fact that when they iterate they have to use the same unit of measure. She asked the class if the paperclips were the same unit of measure. They didn’t think they were. She seemed surprised and asked them if the two paperclips she had in her hand were different. The class couldn’t agree: some said they were different while others thought they were the same. Finally, one girl shouted out that they were the same. Tara agreed with that student. She then placed the 2 paperclips along the marker and asked the class if the two paperclips were long enough for the marker? The class said no. She then asked the class if they had any ideas on how to measure the marker with just the 2 paperclips. A student said, “Put another one,” and another student added, “And then another one” (Day 3 video implementation). Tara told them that she could put another but that she doesn’t have any more paperclips. Another student commented that she was holding the paperclips crookedly; he suggested she make it straight. Another student told her to take their paperclips from their tables. PO suggested she use another one. He said something I couldn’t hear but prompted Tara to say, “Which one? Come and show me” (Day 3 video implementation). PO went up to show her and the class but Tara was having difficulty with the tape. This difficulty was preventing PO from showing what he meant. Tara said, “I think PO is on to something. He’s really using his critical thinking skills” (Day 3 video implementation). From the carpet, a boy, possibly
from PO’s team, asked PO why he hadn’t shared his thoughts with them. Tara
gave up on fixing the tape and proceeded to try something different, “Let me try
to find more paperclips and I’ll give you more” (Day 3 video implementation).
She instructed the students to go back to their assigned groups and she would
give them more paperclips to measure their objects.

Upon return to their groups, I was able to observe one group that was
within view of the camera. The camera in Tara’s class was not manned by
anyone on this particular day. Tara set it up in a corner of her room and kept it
there during the entire lesson. Consequently, I was able to directly see and hear
the carpet sessions and the group that was situated directly in front of the camera
when the students went in groups. I could hear Tara as she visited groups but
could not see her unless she visited the group in front of the camera’s lens. The
group in front of the camera was BG’s group. BG seemed to be the leader. He
told the group, “Let’s measure the marker” (Day 3 video implementation). In the
earlier group session, BG’s group was not always where they were supposed to
be and when they were, they were not working on the activity.

Meanwhile, Tara was roaming and asking questions or commenting on
the group’s work. Some of her questions and comments included: 1) Are you
measuring? 2) You should be helping your partner. 3) I like the way this group is
measuring. 4) Let me see this group measuring. 5) Show me how you measured.
6) Measure it. 7) How many paperclips tall is it?

Back at BG’s group, BG was busy working on the task with one of his
teammates. He told his teammate that their marker was, “Five paper... How do
you spell paper?” (Day 3 video implementation). The two of them worked to
together to sound out the word and spell it. Shortly after that, BY joins her group
and exclaims, “Five paperclips big!” (Day 3 video implementation). Tara arrives at BG’s table and asks them to first tell her the length of their marker then to show her how they arrived at that measurement. BG answered her and then the group counted out loud to show her. Tara asked if one of the units they used was a paperclip and asked them to show her again. She then told them to draw it in the box before leaving for the next group. She announced to the class that if they finished with the marker, they had to measure something else. She had to remind several groups to draw or trace their object and re-measure.

After about 10 minutes of measuring, tracing, and re-measuring, Tara called the groups back to the carpet. She collected their sheets of paper and used it to guide the final part of the lesson: the reflections. She summarized the activity by stating that some groups traced and that some groups didn’t write the lengths they found. She displayed three different drawings and commented that their drawings were fine. She noted that one group measured their marker at 4 paperclips long and another at 4 ½ half paperclips long. She polled the class to see if any other group measured 4 ½ paperclips long. Most groups got 4 and a half. She asked why was it that all the markers were the same but some groups measured the marker at 4 ½ paperclips long while others measured at 4 paperclips in length. A student suggested the paperclips were wrong. Tara countered with maybe the students placed the paperclips incorrectly.

Tara then moved into the reflection and instructed her students to draw their hands and measure its length in paperclips. She then asked the class again to repeat the first instruction. A student answered with drawing their hand. She told them to trace their hand. The same student asked, “Then what?” (Day 3 video implementation). Tara was not prepared (Day 3 reflection) therefore her
directions about writing units were confusing, “If we’re using coconuts... Our unit is paperclips... How do we measure?” (Day 3 video implementation). Different students answered with: 1) make it straight, 2) don’t make space, and 3) same. Tara summarized the three requirements for iterating. She then told them to write those three requirements in the space provided and that they would draw their hand at the back of the piece of paper. She asked EL, “What do you do first?” (Day 3 video implementation). EL responded with the drawing of his hand. She told him no, they needed to answer the question about how to measure first.

**First grade implementation of unit: Collaboration Session 3.** At our day 3 collaboration session Heidi shared that she felt day 3 was better than yesterday. She saw more students had increased their understanding of measuring length. She commented that some students still needed some guidance. Tara wanted clarification. Heidi explained that the students needed her to ask them the “right questions so that they can start thinking about what they are doing” (Day 3 audio after school collaboration session). Tara asked Heidi if her students were able to iterate with just the two paperclips because in her class, no one was able to do it. Heidi shared that no group asked for more but that could have been a result of how she presented the lesson: she didn’t say they could use more. She noted however, that one group iterated the two paperclips they were given then stopped because they didn’t know what to do next. Tara shared that all her students were like that. They weren’t ready to measure “abstractly” (Day 3 audio after school collaboration session).

I told Tara that I expected some students, possibly all students wouldn’t be able to iterate with just two paperclips. Tara was concerned because she tried
asking them about how Jose iterated, “Remember we measured with the
coco-

uts yesterday, what if we only had 2 coconuts, how would we have
measured your height?” (Day 3 audio after school collaboration session) and
they still couldn’t figure out what to do with only two paperclips. However, once
they were allowed to use more paperclips, they could demonstrate iterating.
Heidi revealed that she was under the impression that the students had to iterate
with just one or two paperclips. She shared that because of this, she told her
students that they would practice with just one paperclip. After our discussion,
she shared that if she were to do this lesson again, she would give the students
the option to use more paperclips if they needed.

Tara was intrigued by Heidi’s statement to her class about practicing with
just one paperclip. She asked Heidi to expound. She wanted to know the
mechanics of executing that process: did Heidi write it on the board or did she
talk to the whole class? Heidi told her that she had talked about iterating with
just one unit during the lesson on day 2 before going out, during the reflection on
day 2 after the first outside activity, and then again in the morning of the current
day when she had her students revisit the ideas of iterating. She noted that her
students have received extra doses of mathematics in the past couple of days.
Tara supported Heidi’s extra time allotted for mathematics because of the
richness of the lesson. She cited that language arts was part of this lesson since
students had to write, think, and reason. Heidi agreed and added that the
students were learning how to express length orally and in written form too.
Then Tara inserted that the students were speaking and listening too. She
assured Heidi that since language arts was a part of the math lesson, they could
use more time, if necessary.
I inquired if Tara had done part two of the outside activity. She discussed measurement and their outside behavior as part of the class’s morning business. Then she used her writing time for them to complete their reflections for day 3. Heidi shared that they completed part of their day 3 reflections during math and will finish the following day.

Our conversation steered into the big picture of the lessons. I asked them if they are seeing growth in their students. Both teachers readily believed that growth was evident and “very” (Day 3 audio after school collaboration session) satisfying. They shared that the week may not be enough time for students to master iterating and they anticipate they will have to use more time the following week. Through follow up interviews, both teachers stated that they used more time the following week with Tara needing more time than Heidi.

In addition to seeing growth and being satisfied with the growth, Heidi shared that “a lot has happened in just three days” (Day 3 audio after school collaboration session).

Tara added that her students aren’t accustomed to explaining their thinking. She likes being able to hear them think to give her insight into their minds and consequently, she worries about her questioning techniques. She shared that when she watched herself on the video it was evident that she was struggling with what to ask. This prompted Heidi to wonder if she was questioning her students correctly. I told Heidi that from what I had observed, she was doing fine. She added that she came up with questions she wanted to ask, based on what she had seen with her students and then she reviewed the questions on the lesson plan (she termed them as my questions) and tried to use them too. She then asked if there were questions that I thought she hadn’t asked.
She shared that both Tara and herself would appreciate that kind of feedback. I told them that if I noticed anything, I would share my thoughts with them. I told them that their line of questioning would depend on the amount of guidance the students needed and that as teachers they need to be able to determine how much guidance to give any one student.

This prompted Heidi to share a technique she uses when an entire group is struggling: teach one and let the one teach the others. At this point, I shared that I used the same technique with one of her groups when I was in her class earlier that day. Tara wanted to know more.

I told the teachers that I had noticed a group (AO, LY, and a third student) who believed they understood measurement. I had observed them when Heidi visited with them and heard LY complain that she wasn’t doing anything. Heidi suggested LY watch AO to be sure he was measuring correctly. When Heidi left, I asked AO to show me how he measured. He placed a paperclip next to the object, marked where the paperclip ended with his pencil, then placed his finger (this was a strategy taught by Heidi prior to the activity) where the paperclip ended and moved the paperclip to start where his finger width ended making a finger-width space between the units. When he was done iterating, he counted the number of markings next to the object and claimed it to be that many paperclips long. I asked LY if she noticed anything about the way AO measured. She hadn’t noticed anything. I asked AO if he remembered what one of his classmates had said about spacing. He couldn’t recall. Both AO and LY hadn’t realized that AO’s finger created a space. At this point, AO disengaged for a while probably due to the frustration of trying to understand what error he made. I asked LY to measure the object and to trace the paperclips as she iterated. As
she moved the paperclip to indicate the first iteration, she placed the paperclip slightly above the first tracing. She didn’t use her finger as a marker. After she traced one iteration, I asked her if she saw any space between the units. She realized there was space and did it again. We went through this exercise several times before LY was able to get her paperclip tracings to touch. I lauded her work and told her that it was her turn to teach her teammates how to correctly measure the length of the object. I then left the group to observe Heidi with another group. Tara appreciated my sharing and stated that she might try that technique the next day. She worried about what kind of questions she should ask if her students struggle. Heidi suggested she ask, “Is she making any space?” (Day 3 audio after school collaboration session). She shared that when that didn’t work with a group, she referred to the many examples she did with the whole class and that was her reason for doing so many examples. Tara liked the idea of letting the kids trace the paperclips so that they could see for themselves that they were creating space between units.

Heidi shared, that in the morning she couldn’t resist using JV’s predicted height of 6 feet as a learning opportunity. She reminded the class of JV’s prediction and measured 6 feet of string. She stood on a chair and dropped the string until the end touched the floor. She then exclaimed that this was the height of JV, 6 feet. JV refuted her claim saying that he was not as tall as the string. She used this opportunity to talk about sense-making. She shared that she showed her class a ruler and what an inch looks like because of the number of students in her class that used inches to indicate the measure of their hands in their reflections. She stated that her goal was not to teach them about those standard units of measurement but to generate a discussion about sense-making.
Tara shared that her students had not mentioned inches, feet, or rulers in her class. However, in the subsequent days, a couple students insisted they needed a ruler to properly measure. Tara would counter their requests with, “Did I mention anything about using a ruler?” She never felt compelled to teach her students those standard units. I shared with the teachers that Tara’s kids were much better at stating the unit of measure each time they measured something. Tara commented that was because she was cognizant of this and each time her students left out the unit, she would have them say it again with the unit at the end. Heidi remarked that she never emphasized the use of the unit and that she would be more aware of it for the subsequent days.

Our conversation turned to day 4’s lesson: the hunt. We reviewed the introduction of the lesson where the students would watch the teacher trace her hand and then estimate the tracing’s length. Heidi wanted to know if it would be okay to give the students a choice instead. Her example, “Look at my hand. Would my hand be more like 100 paperclips long or…” (Day 3 audio after school collaboration session). I told her that if her students were having trouble estimating, she could help them through that line of questioning.

We then talked about the hunt itself. Heidi was concerned about classroom management. She worried that 24 first grade students hunting for an object that is 4 paperclips long might result in a messy classroom. She wondered if it would be okay to provide the students with a basket of objects to hunt from. I told her it was her prerogative. I suggested she could also assign sections of her room to specific groups.

Through our discussion, we clarified that the students were not required to trace or check if the object was actually 4 paperclips long but to estimate and write the
name of the object. I then told them that after the groups have identified their object then the plan called for the teachers to bring them back to the whole class setting and that they would call on three or four groups to share their estimated object. The teacher would then take the object identified and trace it on the board (or use the Elmo®) and with the kids, measure the object to check the accuracy of their estimations. Heidi wanted clarification if the objects needed to be exactly 4 paperclips long. I told her that I was comfortable with it being a little under or a little over 4 paperclips long. I shared that I anticipated students would be imagining a paperclip and possibly using their fingers to indicate the paperclip size and iterate with that imagined length. Heidi wanted affirmation that the students needed to round to the closest whole number. I asked them if they had taught the rules of rounding yet. They said it was not a first grade standard. I told them that it might not be fair to ask the students to attend to rules they don’t know. It would be more important to let them round as they see fit, ask them why they rounded the way they did and if the reasoning made sense, then allow for it. In both classes, I noticed that most students said “and a half” whenever anything jutted over the end of the object being measured.

Tara wanted to know what we thought she should do if a student chose an object that was closer to 8 paperclips long. I told her that would mean the student is still struggling with measurement and would need access to many paperclips to iterate. I told her to expect some students to still be at that stage and to allow them to grow at their pace.

I shared that if their classes or groups needed a challenge, they could assign different groups different lengths of the same unit or same number of
units but different units. The teachers didn’t think their students were ready for such challenges.

**First grade implementation of unit: Heidi.** The Day 4 plan originally called for a hunt for various objects of an assigned length through estimation. Heidi followed the plan and gave her students a tub of items to choose from. She asked them to check their estimations afterwards.

In Heidi’s class, she traced her hand and had her students measure its length in the morning. After they measured her hand together, she reviewed each student’s hand because they all wanted to share their tracings and wanted to see if they were right. When a hand measurement was too small or too big, the students were able to catch the error. They were using Heidi’s hand size and the correct hand sizes they had checked together as a benchmark for determining whether a said measurement was in the right range or not.

During her math time, the students reviewed the morning activity with the hands and then were put into groups for the activity of the day. She gave the students a tub full of objects. She told them that they had to find objects or an object that was four paperclips long. They were given two paperclips to use to iterate to find their object or objects. However, Heidi made more paperclips available for students who may need it. As Heidi was roaming she challenged some groups to find an object that was 30 paperclips long. One boy said that nothing in his tub was 30 paperclips long so he looked around the room and chose something longer than what was in his tub. Although it would not have been 30 paperclips long, Heidi believes his understanding of measuring through the iteration of the paperclips is becoming better. I observed Heidi with MI’s group. She noticed that two members were struggling with measuring but
decided not to intercede because MI knew what he was doing. MI noticed his teammates were struggling and proceeded to show them how to measure. He counted out loud as he placed the paperclips alongside the object (a handheld mirror). He counted, 1 – 2 – 3 and when he got to the 4th paperclip, he had it hug the mirror so that it outlined its perimeter, then he stopped, thought about what he was doing, then moved the paperclip away from the perimeter and placed it so that it would be collinear with the other three paperclips. I shared with Heidi and Tara during our after school collaboration session that it would have been nice if Heidi asked MI what he thought about when he made the decision not to hug the perimeter. Heidi figured it was because they had talked about the paperclips not being “crooked” (non-collinear) in the morning during the hand measurement discussion.

First grade implementation of unit: Tara. The Day 4 plan originally called for a hunt for various objects of an assigned length through estimation. Tara followed the plan but asked her students to look for the object from their seats.

Tara started her class by asking them to recall their hand measurements from the previous day. Students were able to share their hand lengths but needed assistance in using the unit associated with their hand measurement. She then segued into asking the students to estimate the length of her hand. Students estimated from one paperclip long to eight and a half paperclips long. The student who estimated her hand to be one paperclip long did so after Tara placed the paperclip on her Elmo® thereby enlarging the size of the paperclip through the projection. It did not seem as if Tara had noticed this. Shortly after placing the paperclip on the Elmo®, Tara decided to trace her hand on a sheet of paper and project it. She was shocked at the size of her hand and trashed the idea
of using the Elmo®. During our collaboration session after school, I told Tara that it would have been okay to use the Elmo® because it proportionately enlarged both her hand and the paperclip. The only source for confusion would have been if her students already had the paperclips on their desks. But since they didn’t have the paperclips with them, it would have been okay to use the projection for illustration purposes. Another possible source of confusion would have been Tara changing the unit from the previous day and from the morning. Because she did not have many of the paperclips she used on day 3 and in the morning, she switched to the larger paperclips that she had an abundance of for her students to be able to line up the paperclips to measure. Tara reflected that she needed to be better prepared with her materials and her technology for the next time she does the activity.

Since the projections were not working to her liking, Tara switched to her traced hand on the white board and taping the paperclip next to her hand. Tara wanted her students to think about their estimations so she asked them to look at the paperclip and look at her hand and make another conjecture. She wanted them to notice that her hand is bigger than the paperclip.

When she taped a paperclip perpendicular to the bottom of her hand, she asked the class if they thought she put the paperclip in the right place. They didn’t think she had. She told them she had placed it correctly and asked them where she should put the next one. A student told her to put it at the bottom. Another student told her, “In the other one” (Day 4 video implementation). More students chimed in and told her to put it on the top. Tara purposely put the paperclip above her traced hand and asked the students if that’s what they meant. They said no. A student told her to make it the 2nd one. Tara then asked
JP what he meant by on top. JP told her it needed to go on top of the other one. She then placed it above the taped one, oriented in the same way, and with a gap between the two units. From the students’ perspective, they could not see the gap. They were shouting that she finally got it right. When she moved to the side of her tracing, she revealed how she had actually taped it and asked the students if that is what they meant. They were in the middle of saying yes when they saw the gap, they changed their answer to no. JP exclaimed that the units had to be close and gestured by having his two hands, fingertip to fingertip, touch each other. He told her not to create a space between the paperclips. At this point, two paperclips had been correctly taped to begin to show the length of her hand. She asked the students if her hand is 2 paperclips long. They said no and one student said she needed more. Tara asked for clarification. The same student said she needed one more. Tara noticed that original segment she was creating with the paperclips wouldn’t hit the longest part of her hand so she shifted her segment a bit to the right. As she was doing this, a student noted that she was placing them crookedly on the board. She acknowledged the student’s comment and told him she was working on making it straight. Before taping the third paperclip correctly on the board, she intentionally made more errors for the students to analyze her placement. Once the paperclip was fastened correctly, she asked the students if her hand was 3 paperclips tall. They told her no and that it would be three and a half paperclips tall. Tara asked the students if she measured all the way to the top. They said she hadn’t. She then asked the students what she needed to do. They told her she needed one more. She began to point out that when she tapes one more, she would be three and a little more paperclips tall. But before she could share the size of her hand, the students finished her
sentence and told her that her hand would be three and a half paperclips long. She agreed with them because she noted that the 4th paperclip wasn’t quite a whole paperclip to the top her hand. Tara had the students count the iterated units aloud. The students counted 1, 2, 3, 4. She stopped them and reminded them that it’s not quite four. They corrected themselves and said three and a half instead. Again, Tara had to help them remember to say the unit after the number.

After measuring Tara’s hand, the students were told that they would continue to iterate. She reviewed the concept of iteration with her students and then brought the students to the work of day 3 to remind them that they had iterated objects in the classroom. At this point, she showed her students her whiteboard marker and asked them to think about how tall they thought it was.

GI said five and a half. She reminded the students that they were using the same paperclips that they used to measure her hand. Another student conjectured three and a half while another student said four and a half. After listening to the estimates, she told the students she would tape the marker to the board for all to see. She then said, “Everybody, I want you to think. Look at the paperclips... About how many paperclips tall is this object?” (Day 4 video implementation). GI kneeled and used his thumb to try and estimate the length of the marker. Tara then told the class, “I’m going to give you thinking time” (Day 4 video implementation). GI then went closer to the marker to get a better estimate. Tara told him to sit down. Other students seemed to be misbehaving as Tara had to stop at several points to remind the class to be quiet. Through her reflection, Tara realized as she watched the video that what she deemed as misbehavior was students trying to make sense of the measurements. She noted
that she thought JH was playing around but upon inspection of the video, he was actually using his thumb to try to figure out the estimation.

Some students started to give their estimates but Tara was insistent they thought about their estimate before giving an answer. Four hands shot up at various times during the thinking time. One girl was lightly pounding her head to indicate she was thinking. As more thinking time passed, 12 hands were in the air. Tara then called on EU to share his thoughts with his peers. EU said he believed the marker to be one and a half paperclips tall. Tara then called BY to share her thoughts. BY said the marker was three paperclips tall. As Tara wrote their musings on the board, she told the class that they could say tall or long. She encouraged them to use long from that point forward. She told them because they were going to use the word long instead of tall, they would be measuring length. A student then asked out loud, “What’s length?” (Day 4 video implementation). Tara announced that one more student would share his or her thoughts. She called on JA to share her thoughts. JA said the marker was four and a half. Tara asked JA if she thought it would take four and a half paperclips to measure the one marker? A student said no. Tara reminded the student that it was JA’s turn to guess. JA then said three. Tara asked her what she meant by three. JA then recanted and said three and a half. Meanwhile, another student on the carpet was gesturing the #2 with her fingers to share with JA her thoughts. JA then said three and a half paperclips. Tara asked her to complete her statement. After thinking, JA said three and a half paperclips long. Tara wrote her conjecture on the board and told the class they would see whose estimate is correct. For this part of the activity, Tara had her students measure various
objects on the board beginning with the marker. They would illustrate their measurement by taping the paperclips along the objects being measured.

After the review session, Tara had her groups search the room with their eyes to locate an object that is four paperclips long and write the name of the object on a piece of paper. She reminded the students of each taped object’s measurement on the board by writing the measurements and saying them out loud. Tara pointed out the different items in the room such as the fan, the computer, the poster, the ball, markers, erasers, and more. She asked the students again to tell her what they were looking for while she held up four fingers. Some students said four inches tall. Tara asked them if they had talked about inches at all. She asked JH if they were measuring in inches. JH said yes. She then directed her question to the class. The class told her they were measuring with paperclips. One student clarified by saying they were using big paperclips. Tara agreed that they were using paperclips that were a little longer than the paperclips they had used in the morning. Tara repeated her directions many more times in various different ways before distributing a piece of paper for the teams to think and then write what they thought was four paperclips long. She told the students that she would roam and give the students paperclips to help them estimate once they’ve written their initial object. At each group, she had to remind them that they needed to write the name of the object on their sheet of paper. She had to remind one group they did not need a ruler. She urged the class to look around and pick anything in the room to guess to be four paperclips long. As she roamed, one group had the word pencil on their sheet. She asked them to be more specific. The boy of the group held up his pencil to indicate that was the pencil they were referring to on their piece of paper. Tara instructed them to hold
on to their pencil. As she circled the class a second time, most teams had a guess but still had not written the word onto their piece of paper. I heard another group decide that one of their pencils was four paperclips long and another group conjectured that their water bottle was four paperclips long.

**First grade implementation of unit: Collaboration Session 4.** At the after school collaboration session, Tara reported that she finished day 3 in the morning. As her students continued to measure in the morning she noted that they were working on issues with overlap and miscounting. During her math time lesson, I noticed that overlapping was no longer problematic. However, whenever a fractional unit was involved some students had difficulty counting the “half”: this is what they all called anything that was jutting beyond the object’s length. I observed Tara work through counting these measurements each time.

As we continued to talk about day 4’s lesson, I shared with Heidi that I am in awe at the amount her students learn because when I observe her class, it seems as though they aren’t listening to her but then they surprise me with the comments they make. Heidi concurred. She noted that when I left her room, the students quieted and she wondered if they were learning anything at all. She commented that IN surprised her because he seems to understand the concept of measuring really well despite the fact that he is always talking to others. Tara interjected that she “can’t stand teaching like that,” she feels like she has to “yell” (Day 4 audio after school collaboration session). She shared that she “finally brought the kids to the carpet because I felt like I didn’t have their attention” (Day 4 audio after school collaboration session). This led her to tell us that management is more difficult in this setting. Her comment caused me to ask, “Wait, you said when you teach like “this”. So how do you normally teach?”

87
(Day 4 audio after school collaboration session). She shared that she normally teaches new concepts from the carpet. Teaching new concepts to the class when they are at their desk is difficult for her. I asked her why she didn’t keep them on the carpet if it was easier. She noted that since she had them sitting in their groups (this was also a different seating arrangement from her normal whole class group seating), she simply forgot to bring them to the carpet first.

Tara asked Heidi to describe how she did her lesson. After listening to Heidi, Tara realized she did her lesson differently and wanted to try Heidi’s interpretation of the lesson. She said she would execute Heidi’s interpretation in the morning of day 5.

The last 15 minutes of our collaboration session focused on day 5. Now that we were closing our 5-day lessons, we recapped what we had done so far and how it fits into the modified timeline. We reviewed that the story needed to occur over two days. Day 3 would be a day to measure objects in the class and day 4 would be a day to hunt for objects of an assigned length through measurement and not with a focus on estimation as what was originally planned. The lesson plan asked for day 5 to be a day to compare lengths of different units by using the language of comparison (A is longer than B but shorter than C). Because we hadn’t had time to attend to the conclusion of day 4, I felt that we needed to do it and we needed to do it as a whole lesson instead of just as the concluding activity for the hunt. The concluding thought of day 4 was to present students with an object that they had measured as four paperclips long and then tell them that the teacher measured it and found it to be 3 or any other length and ask the students, “What’s going on?” I shared with them that I thought this
was important to do as an entire lesson based on my observations of the students and their learning. I asked them for their input.

Heidi and Tara were very excited about doing this lesson. They wanted to see if students could notice that the unit the teacher used must be different. It was a nice way to bring the lessons back to the story where Jose measured different heights depending on the unit used. Tara was concerned that if we say the units in our question, it would be giving too much away. I told her that she had a good point and that they could start off by not mentioning any units and see if the students could respond to the question. I suggested they tell the students that their measurement is correct.

Heidi responded that she would prefer not to tell them anything leading in the beginning. I agreed with her and suggested that if the students were struggling, then she could tell them that both their measurements were correct so, “What’s going on?” I also shared that if students were struggling to articulate that the measurements were different because the units used were different, then the teachers can feel free to repeat the situation but mention the units to see if that might help the students.

Heidi asked if she could model the way she would introduce the lesson and I said sure. She started with having the students recall their measurement from day 4 as five paperclips long and then telling them that her measurement was six units long. She shared that she would leave out “bears” as her unit in hopes of them saying that she’s using bears and not paperclips causing her to have a different measurement. Heidi then thought that in order for them to be able to recognize that she used a different unit they would need practice measuring length with the bears. Tara and I agreed. The lesson would begin with
her students measuring a variety of objects using the bears as their unit of measurement. The activity would serve two purposes: 1) More iteration practice, and 2) Give the students an understanding of the unit “bears” so that they may be able to recognize that different number values result when different units are used.

Tara was concerned about what kind of questions should she ask when the students were measuring in their groups. I told her that since her students would be measuring with the bears, she could ask the same types of questions she asked when they used paperclips. If she noticed groups measuring with ease, she could challenge them by asking them to recall how many paperclips long the specific object was and comparing it the measurement they got and ask, “What’s going on?” If the students have difficulty expressing themselves, she could ask them if the object changed in size to get them to see that something else must have changed: the unit. Tara and Heidi realized that for this lesson, it should become more obvious to the students how important the unit is.

**First grade implementation of unit: Heidi.** The modified Day 5 plan called for the students to measure with a different unit and then to present them with a situation similar to Jose’s dilemma where the students have to explain why an object they measured at four paperclips long was measured by the teacher at 6. The goal for the day was to get students to think about the direct relationship between measurement and the unit. The students were able to discuss the significance of the unit during her morning session but not when I observed her class.

Heidi’s mathematical discussion took place during her morning math session. She reported during our after school collaboration session that the
students seemed to understand the idea of the unit very well. As she and her students were going through different examples of units, her students started naming objects in the tub of things they measured. This caused Heidi a mild panic attack. She was wondering if her students were just naming items in the tub or if they understood that the items in the tub could be units. As she was thinking about how to phrase her next question, a student listed soil as a possible unit. Other students chimed in telling the student that soil would be too small and that it would take forever to measure anything with soil. This discussion made Heidi believe that her students were naming the items in the tub as units. She steered the class back to her attention and asked the class if she could use her eraser as a unit. They said yes. She proceeded to measure her white board with her eraser. When they were done, she asked the class to define iterate. They told her it was to repeat the same unit. She picked up another eraser and asked the class if the two erasers were the same unit. Her class said no. She did this several times and her students insisted they were different. She asked them to identify each object in her hand. They identified both as an eraser. So she said that made them the same unit but that they were different sized. She told the class that they should amend their definition of iterate to mean to repeat the same-sized unit.

During Heidi’s afternoon mathematics class, she took a mirror from the tub and had her students measure the mirror in paperclips. Then she measured the mirror using the teddy bears. They recorded the student measure at 4 units and her measure at 7 units. She then took a poll. She asked the students to vote for which measurement they thought was correct, 4 units, 7 units, or both. One student voted for seven because it was the largest number. The rest of the class was about split with 4 units besting both by one vote. She decided to bring the
The students were able to recall the different measurements and they were able to say that all Jose’s measurements were correct. This prompted Heidi to take re-poll the class. Seven units was no longer voted for and both dropped one point. Heidi did not correct her students, instead, she made note of the results and vowed to revisit the idea the following week. Tara liked the poll idea and stated that she would try that next week.

**First grade implementation of unit: Tara.** The goal for the day was to get students to think about the direct relationship between measurement and the unit. At the end of Tara’s lesson, in response to her question about why the value of one measurement differed from the value of another measurement of the same object, one of her students stood up from the rug with the linker cube (the unit Tara used to measure the object) and said, “Because the paperclip is bigger and the linker cube is smaller. That’s why they’re (the numbers) different.”

Tara’s class looked very much like Heidi’s day 3 with the use of a different unit, the linker cubes. She began her lesson with her students on the carpet and reviewing the word iterate. The students started by calling an iteration a measurement. Tara agreed they measure when they iterate but she wanted to know what they knew iterate to mean. A student answered that iteration meant tracing. Tara told the students that iterate “means to use the same unit of measure over and over again” (Day 5 video implementation). She then asked the class what were some of the requirements for proper iteration. Her students were able to convey the requirements. She then proceeded to explain the activity for the day and revealed that at the end of the lesson, they would reconvene at the carpet to compare their measurements.
As she organized her students into groups, she distributed the linker cubes and the paper and repeated the directions of first tracing and then measuring. Then, she roamed the floor checking for understanding.

Students were at various levels of being able to explain a measurement. One group dynamic included BS teaching CT how to measure and GL seemingly disinterested in the activity. BS asked CT if he was measuring anything. CT quickly picked an item out of their box and proclaimed it as his. BS showed CT how to measure his item. As the two boys were engaging in a conversation about measurement, GL interrupted their dialogue by continuously poking a pencil into BS’s workspace. CT became upset and asked her to remove her hand and the pencil away from their work station. BS continued to show CT that he had to align the linker cubes parallel and flush against his object. He then showed CT how to count the length of the object and where to write the measurement on the sheet of paper. CT was standing and hovering over BS’s shoulder as he was demonstrating how to measure. CT decided BS should write the measurement for him and gave him his pencil. GL was not paying attention to the exchange between BS and CT. Once BS was done, the two boys started to talk about fighting. Once the tale had been spun, BS resumed working for a short while then went back to his story about fighting. When GL noticed the boys were done with measuring she announced that it was her turn and asked BS to show her what to do. The object she chose to measure was an unsharpened pencil.

GL didn’t have a writing tool to trace her object so she tried to grab the pencil from BS. BS wouldn’t let her take his pencil. GL explained that she needed to draw. Meanwhile, at another group (BJ, FK, and another boy), BJ was
returning from a voyage to another group, “He said how many linker cubes long” (Day 5 video implementation).

In the background, Tara could be heard asking JH what he needed to do next. The next thing I heard was Tara helping JH iterate by showing him how to do it. She noticed that BJ and FK (JH’s teammates) were not on task. Eventually, she handled this group by announcing to the class that some groups were working well. Upon hearing this, BJ took their group paper and began to measure an object that was already traced by FK. BJ put 4-linker cubes flush against the tracing and counted the linker cubes. While Tara was visiting with another group, BJ handed her their completed work. She announced to the class that one group was done.

She walked to BJ’s group and asked FK what he wrote as his measurement of one of the objects. FK told her it was one and a half. She asked him to clarify. He said that it was 1 and ½ - linker cubes. She asked him to further clarify. He said that it was 1 and ½ - linker cubes long. She returned their sheet to them and reminded them to include the unit and the word long. FK took the paper and wrote the units for the various objects. In less than a minute, FK announced to his group that they were done. Tara returned to their group and asked them to show her one of the measurements. She asked the group what the unit of measurement was for the day. FK told her it was linker cubes. She went through the exercise of using the units with FK again. Then she asked JH to measure an object again. Tara had to leave BJ’s group to attend to some behavioral issues in another part of the room. This did not deter BJ. When they finished fixing the other items, BJ brought their paper to Tara. Tara took their paper and walked back to BJ’s group with him. She asked the group to show her how they
measured. She turned to face an adjacent group and asked them to show her how they measured. She asked BJ to show her how he measured the pencil. BJ showed her and saw that the measurement he had written on the piece of paper was too short. She then went through the exercise of getting BJ to completely state the measurement to include the unit and the word long. She instructed the group to fix their error and left. FK fixed the error and gave it to BJ to give to Tara.

Tara examined their completed sheet. She returned it to him and the two of them walked back to BJ’s group. She told FK that they had a question for him, “because BJ is not quite sure… how to write the length of this block” (Day 5 video implementation). FK told her the block was one and a half. BJ was distracted. Tara reminded him that he needed to get information from FK. BJ repeated what FK had said. FK told Tara that he had already written one and a half.

**First grade implementation of unit: Collaboration Session 5.** The day 5 after school collaboration session began with me getting all the footage I needed onto my computer and ensuring that I received copies of their daily self-reflections. Then Heidi shared about her day, both morning and afternoon, with us. She was okay with the fact that some of her students still hadn’t quite grasped the idea that the unit affects the measurement because she was determined to go back again. I gave her some ideas for when she could weave the idea of iterating into math lessons. I pointed out that she could have the students practice some more when they learn about comparing lengths or sizes or she could have them iterate the pictures in a pictograph when they learn how to graph. Heidi was excited about continuing with this concept. In fact, whenever
I see Heidi outside of school, she feels compelled to share the progress of her students in mathematics. Her enthusiasm is apparent.

Tara summarized her lessons of the day as “talking, work, talking, work, and review” (Day 5 audio after school collaboration session). Tara shared that she feels her students are moving forward with their understanding of measurement but she worries because she can’t get responses from all her students. She is aware that certain students haven’t spoken to her yet and tries to get them to talk by telling the class that she hasn’t heard from the particular students and that she wanted to know what they were thinking and what they have learned.

In response to her challenge, I asked her if she normally does stations for mathematics. She said no and Heidi responded that she sometimes does it but doesn’t find it to be a good system for mathematics. I shared what I knew of their class structure based on our sessions. I noted that she has her morning business and she has used that time for reflections. I wondered if that could be a time to interview the shyer students to get them to talk to her. Heidi shared that three of her boys were not very forthcoming with their thoughts either. She had them sit for a long while thinking about their behavior. She shared that she plans to sit with them and talk to them to see where they are in their understanding of measurement.

I asked the teachers if there were any issues with the lesson. Tara shared that she often experiences her students not always being on task. She recognized that it wasn’t an understanding issue but it bothered her. Otherwise, there were no other issues.
**Fourth grade planning sessions.** There were three 4th grade planning sessions. One in May, June, and August 2012. The 2-hour May session was a chance for the teachers to experience the lesson as a student and a chance for the teachers and I to identify any issues in the lesson. The 45-minute June session’s goal was for the group to go over the lesson, think about what can be done to improve it, ask the teachers what they liked and what they didn’t like, and how can we change parts of the lesson while keeping the idea of ethnomathematics, and the ideas of fishing and conservation through the Size Matters Campaign in the CNMI. During the 1-hour August session, we met to review the modified lesson. The purpose of this final planning session was to address lingering teacher concerns, review the lessons, and introduce the modifications made.

During the August session, I acted as the teacher and the teachers acted as the students (with their teacher hats on at the back of their minds). I told them that at our June meeting, we would discuss the lesson. I executed the lesson as I saw it with the exception of day 5-8, the research portion of the lesson. Since we had to cram four days of students lessons into two hours, we had to speed through some parts of the lesson. The teachers faithfully played their parts and experienced the lessons as if they were students. At the end of the session, I reminded them to think about the lesson and any issues they may have had with it.

When we met in June, the teachers re-read the lesson plans and discussed its components as issues arose. Minor changes were made to the lesson. The changes suggested included changing the introduction to estimation to a reminder (Betty). Roxy suggested that since day 5 was a research day, the kids would need more than one day: we changed it to 2 days with a 3rd day for their
presentations. Roxy noticed that the details about the graph to be created from the research mentioned fractions but since the emphasis during the lesson was on decimals, the fractions should be changed to decimals: it was changed and after Roxy’s implementation, the graph requirement was removed from the lesson.

The final planning session introduced a change to the one of the lessons in the unit: the lesson on decimals. I shared with the group that I felt that the lesson on decimals lacked depth. I asked them to consider using base ten blocks instead to facilitate the learning of decimals. It was established by the teachers that this would be the first time the students would have exposure to decimals according to the Common Core standards. As such, it would be imperative that this lesson allow for many experiences with conceptual understanding of decimals. Although none of the teachers had used base ten blocks to teach decimals, they were willing to try. I spent about 30 minutes showing the teachers how to use the base ten blocks for the lesson. This included tying the subsequent lessons in the unit to include the use of the base ten blocks. I was also worried about the use of the table to show patterns between inches and feet and other units of measurement because I assumed, when writing the lesson, that this would be a review for the students. Upon reflection, I considered that my assumption might be wrong. I asked the teachers to tell me if they thought the table would be review or new. If they had said new, I would have removed the table but they told me that they believed it would be review for most of the class. After Roxy’s implementation of the lesson, I realized that the table, although a nice way to organize pattern thinking, didn’t belong in the big mathematical idea of the lesson: understanding tenths and hundredths. The second half hour was spent
on reviewing the other components of the lesson and setting up our implementation dates.

**Fourth grade implementation of unit: Roxy.** Day 1 in both classes began with the students drawing a fish, real or imaginary. Students from both classes were excited to draw. SI used feet as his unit and used his foot as the equivalent to one foot. Others in her class use their thumbs but some issues arose with some of these kids: some were not paying attention to how they iterated or didn’t know to pay attention to where the last thumb ended as a place to start causing much overlap. Other students used the tips of their thumbs as their 1-inch unit. Her class then segued into the lesson on the table that was eventually removed from the unit.

Roxy used the thumb referent as a way for students to re-measure their fish (before the table part of the lesson) and then have her student pairs check each other’s work using the thumb. The discussion that resulted from this activity was the best part of the lesson for her. The discussions allowed her to interact with the student pairs, ask questions, and listen for the reasons for the differences in estimations when both students used the thumb referent.

**Fourth grade implementation of unit: Mindy.** This part of the lesson was Mindy’s favorite because of the level of excitement and interest her students had in the activity. She shared that she had never done anything like this before because she felt “limited with time and having to cover many standards within a quarter” (Day 1 reflections). After the students had drawn their fish the students were asked to define *estimate* and then estimate their fish’s length and width. All students in her class used inches or feet as their unit for estimation. Some students seemed to understand estimation well. While the teachers were
roaming, Mindy suggested they use their thumb to measure the length and width of their fish. A student in her class shouted out that the thumb would be an inch. One girl measured the length of her fish by measuring the outline of its body with her eraser. Some kids used their forearm but mentioned that her forearm was equivalent to 3 inches. One girl shared that her fish’s length was 30 inches (the sheet of paper they used was 16 inches long) but how she measured was not observed. Mindy used the table that Roxy used in December despite the fact that it was already removed from the unit. She had done it because she watched Roxy’s video and followed Roxy’s sequence.

After the table, Mindy referenced her suggestion about the thumb as a unit of measurement and asked, “What can you say about that? Is using your thumb pretty accurate?” (Day 1 implementation video). RN said, “You can’t really tell how long your thumb is” (Day 1 implementation video). And JN chimed in with, “Everyone’s thumb is different. Some are shorter.” (Day 1 implementation video). With that, Mindy ended her lesson with a review of measurement using a video from www.brainpopjr.com.

**Fourth grade implementation of unit: Collaboration Session 1.** During our after school collaboration session, Mindy revealed that, “Since they didn’t really do so well on their own (estimating length and width), not everyone was able to do it on their own, that was a good visual” (Day 1 audio after school collaboration).

Mindy reflected that it had been “a while since she used this instructional approach to teaching” and that she typically does a “powerpoint [sic] lesson, practice, and then assessment” for her math lessons (Day 1 reflections). She commented that she “miss(es) working with lessons like these” (Day 1
reflections). She noted however that after giving this type of instructional approach a chance, she was able to adjust to the style. Roxy noted that teaching in a whole class setting was different for her. When I asked her to clarify during our after school collaboration session, she revealed that she typically teaches a 10-15 minute mini-lesson and then separates the class into three groups (the workshop approach she spoke about during our October collaboration session) according to the math level for station work. I asked her if we could tweak the lessons to suit her style. She said she would keep the whole class setting for the next day since she would be reading the story to the class but would make adjustments for day 3.

**Fourth grade implementation of unit: Roxy.** Day 2 began a little differently for the two teachers. Roxy wanted to clarify some pattern questions she had from the previous day so she opened with a student sharing a pattern he had done. Once she was clear that they understood the student’s pattern, she brought the students back to their fish and asked them if their fish was okay to eat. Both teachers spent about 10 minutes with this question. They both asked their students to share their thoughts while Roxy asked her students to keep in mind that they should be thinking about math as they consider the question. Her students responded in the affirmative because it was “big and has lots of meat” or “because it’s so fat” or “you could cut it in half and share” (Day 2 reflections) or “it’s a good amount for my whole family” (Day 2 video implementation). The students who said no reasoned that it was because their fish was make-believe or something about the way the fish looked made it inedible (sharp teeth, scary looking).
Next, Roxy spent about 5 minutes getting the students ready for the story (Miura, 2011). She connected the story to her students’ lives by asking them if they’ve ever gone fishing with a relative after telling them they would be listening to a story. That elicited excitement amongst the students as many of them shot their hands up to indicate that they have fished. She asked the students to keep in mind their fish and think about whether it’s okay to eat or not as they listen to the story. As she read the story, the students seemed interested. During the reading, Roxy stopped at different parts in the story to check for comprehension and point out some of the language arts connections. In addition to stopping at the language arts connections, she stopped when an opportunity to point out measurement and when the Chamorro sentences in the story were read, she asked the students to translate the Chamorro or read those sentences. She planned and rehearsed reading those sentences the day before and was surprised when she froze when it came time for her to read the Chamorro words in the sentence. One student commented, “I thought you were Chamorro” (Day 2 video implementation). She quickly improvised and had her students read the rest of the sentences for her. Most students were able to translate based on the context of the story while a few understood the Chamorro. In the story, Uncle Greg takes his sons out on a fishing trip. His first son catches a fish and shows it to his dad. His dad tells him it is too small to keep and he must throw it back in the sea to allow it to grow and lay eggs. Roxy asked her students to tell her what Uncle Greg did to determine that the fish was too small. Her students responded with, “He measured it with his arm” (Day 2 video implementation). She commented that her students were engaged in the story and were able to respond to her questions during the comprehension check. She noted that they
enjoyed the Chamorro language in the story. They continued to talk about the story in their CCLHS class and after school. At the end of the school year, Roxy allows her students to select several stories to be reread as a way to recap the year and they voted to reread this story. Roxy reflected that she liked how her students were able to “relate the events in the story to that of their real lives” (Day 2 reflections).

After the story, the students searched for a fish from the poster of the Size Matters Campaign that was most similar in size to the fish they drew, write the name of the fish, compare the sizes of the two fishes and write the difference in size between the two fish. Roxy required her students to write the L50 measurement of their fish. Both teachers misunderstood the intent of the lesson was to have the students look for a fish that was most similar in appearance to the fish they drew then compare the sizes to see if it would be okay to eat. After Roxy’s class, I had amended the lesson plan to be more explicit.

Roxy shared that her students were using different units of measurement when comparing their fish to the ones on the poster. Upon looking at their recording sheets, she noticed that some students used centimeters, inches and feet when the measurements on the poster were strictly in inches. She felt that some students misunderstood the questions on their record sheets and realized that she should have reviewed the questions with the students to check for understanding before having them engage in the activity.

Upon reflection, Roxy would like to change the way the story was read. She suggested either having the story pre-recorded or including other readers to

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1 The L50 measurement in the Size Matters Campaign in the CNMI
play the roles of the characters in the story to help her with the Chamorro sentences. She also suggested giving each student or pairs a copy of the story for them to be able to follow along in a reader and for her to be able to call on readers.

**Fourth grade implementation of unit: Mindy.** Mindy started her lesson by asking her students if they thought their fish was okay to eat. Then she expended about 10 minutes preparing her students for the story. This was Mindy’s first time to use a story to teach math. She previewed the story using a PowerPoint presentation of four words from the story that she felt would impede student understanding of the story. Her first slide showed the four words and her subsequent slides followed the pattern of a word and its definition, followed by the sentence from the story that includes the word. She used the second slide to have the students explain the meaning of the sentence. After the slideshow, she reminded the students that they will be reading a story to see what Uncle Greg, the main character, thinks about the size of fish. She asked her to students to conjecture why they thought Uncle Greg would know how to judge if a fish is okay to eat or not. Student responses included, “Because he has things to measure with,” “He has a book about poisonous or dangerous (fish),” and “I saw a poster and it said if it’s okay or not” (Day 2 implementation video). As she read the story, students seemed interested and attentive.

Mindy chose to read the story straight through and then review the story afterwards. She reflected that a “handful of students weren’t able to really recall the story” (Day 2 reflections). She was surprised that her students were unable to connect the ideas of the story to their drawings of their fish.
After the story, the students search for a fish from the poster of the Size Matters Campaign that was most similar in size to the fish they drew, write the name of the fish, compare the sizes of the two fishes and write the difference in size between the two fish. Once again, Mindy relied on the videos of Roxy’s implementation to help her lessons and therefore did the same thing as Roxy.

In Mindy’s class, since they only had one poster to compare their fish to, Mindy had the students take turns going up to the poster to compare. The students at their desks were instructed to add details to their fish or the fish’s surroundings. Mindy noted that her students were confused with the directions. During the after school collaboration session, it became apparent that Mindy was confused with the directions herself. She offered to do the lesson again. I told her that it wouldn’t be necessary but that we should review the big picture of the unit before we proceed to the next day.

Mindy reflected that she would like to add more vocabulary to her PowerPoint presentation to help the students better understand the story. She would change the last reflection question for the students to read, “What would Uncle Greg say to you about your fish? Would it be okay to eat it? Why or why not?” (Day 2 reflection). We had discussed this during our after school collaboration session. We decided that it may have helped her kids connect their drawings to the story if Uncle Greg was explicitly mentioned in the question.

Fourth grade implementation of unit: Collaboration Sessions 2 and 3. During the after school collaboration sessions, we used that time to share the general impressions of how the class went, troubleshoot and clarify some areas of confusion, and prepare for the next day’s lesson.
During Roxy’s after school collaboration session, Mindy was in attendance and contributed to some of the discussion. Through these discussions I learned that Mindy’s definition of the use of models was showing a PowerPoint presentation. Roxy commented that she felt her students would be able to anchor to fractions when learning the decimals because they had a good sense of fractions from earlier lessons. Mindy responded that it was good she was not implementing our lessons yet because she was just starting on fractions with her students and that even with the modeling (a picture on PowerPoint that shows a square, then the PowerPoint breaks the square into parts and shades it), her students were not grasping the concept of fractions. I asked Roxy to share what kinds of modeling she had her students do with fractions and she revealed using rectangles and circles. I suggested Mindy allow her students a chance to do some hands-on activities with fractions as a way to help them understand fractions. She responded with, “I’m going to try if they can show me… I want them to tell me at least equal parts” (Day 2 audio after school collaboration session). Mindy required some understanding of fractions before her students could use manipulatives.

During Mindy’s after school collaboration session, I asked her if she was going to try to separate the students who struggle from day 3 or from days 3 and 4 to help them with more practice with the manipulatives and with the regrouping of a number in the tenths (like four tenths) into hundredths. I told her that Roxy had done it and it was a huge success. She was able to bring more students into the understanding zone. Mindy showed no interest in trying Roxy’s method. I stopped talking about the grouping and moved to discussing
the rest of the next day’s lesson and continued to talk about the subsequent lessons. After much discussion, we ended our session.

**Fourth grade implementation of unit: Roxy.** Both teachers felt the day 3 lesson went well. Roxy felt it was well organized and she liked the progression of the lesson. Roxy began her lesson by asking three student volunteers write the L50 lengths of their fish on the board. She used the values given by the students to spark the discussion to introduce the lesson. She asked the students to look for something all the numbers had in common. Students first answered by noticing the decimal point in the numbers. Then Roxy asked her students to elaborate on what they meant by decimal. One student said, “and” and another student added “it’s smaller than one” (Day 3 reflections). She then explained that the decimal value represented part of a whole.

She explained that the decimal value represented part of a whole. She then showed her students the base ten blocks and picked up the thousands cube. She asked the students if the large cube was the whole, what would .5 look like. A student from the other class 2 was able to say that it would be half of the cube. She believed that the students in the other class had some experience with decimals because of the mixed grade levels. She then proceeded to ask them how half would be represented using the set of cubes, flats, and rods she had on the table. That same student said five hundreds. She then asked the class what .6 would

2Roxy began her school year with all the students in her current class. After some time, the school decided to reduce her class size and split her class into two giving another teacher a mixed class of 4th and 5th grade students. Again, after some time, the school decided to bring the students in the mixed class back to Roxy’s class.
look like using the blocks. They weren’t able to answer immediately. Roxy then asked the class how many flats were needed to make the cube. One student said 10. She then asked the class what fraction of the cube one of the flats was. The class was able to identify it as 1 out of 10. With Roxy leading the discussion, she asked the class to name the fraction as she placed an additional flat to her pile. “I think that this lesson was successful in a sense that most students were able to build upon their understanding of fractions” (Day 3 reflections).

Following the whole class introduction to decimals, the students were allowed time to express their L50 fish measurements with the base ten blocks while Roxy roamed the class and asked them questions to check for understanding. Roxy had one thousands cube and several flats on the table for students to use if necessary. The students had to cut and paste their paper base ten blocks onto their paper to represent their L50 measurements. Roxy enjoyed listening to her kids as they reasoned their representations.

Roxy would have liked to given each group base ten blocks to manipulate instead of just the paper print outs of the base ten blocks. “This was the first time I used base ten blocks to teach about decimals. Last year I used money to teach decimals. I think students this time were making better connections with the concept when asked to think about the construction of the whole as a fraction” (Day 3 reflections).

Roxy was unable to complete the objectives of day 3 due to time constraints and consequently, the revised lesson plan split day 3 into two days. The first part of day 3 was an introduction to decimals and the tenths place through the use of the base ten blocks. In this first part, the entire 40 – 45 minutes
was used when the teacher led the discussion and then gave the class time to practice using the base ten blocks. The second part was where day 4 begins.

Roxy reviewed the naming of decimal values to the tenths place and the reasons behind the name. She then segued into decimal values to the hundredths place with the problematic fish poster she created that displayed 8.07. Her poster showed a representation of 8.07 using the base ten blocks. The representation was 8 cubes and 7 flats. It indicated that she was wrong on the poster and asked the class to correct her. As anticipated from our collaboration session the previous day, the students corrected her poster by telling her that 8 cubes and 7 flats represented 8.7 so the decimal value on the poster was wrong. She lauded the class for telling her the correct decimal value that she represented but she also wanted to know how to represent 8.07 with the base ten blocks. After some guidance and discussion, the students were able to see that seven rods represented seven hundredths. She found it surprising that her students could explain that a flat represented a tenth of a whole but many found it difficult to explain that a rod represented a hundredth of a whole.

Although her students were having some difficulty explaining that a rod represented a hundredth of a whole, she continued the lesson by asking them to compare two numbers like 3.7 and 3.75. After some whole class practice with comparing two numbers like the example, she separated the class into two groups: her advanced group and the group of students still struggling with representing and comparing decimal values. About two-thirds of her class was struggling. Her advanced group remained in her class researching overfishing on the internet using a sheet of questions Roxy had provided for them to answer. Her struggling students went to the counselor’s room with Roxy (and I followed
to observe) for remediation. Roxy provided this group of students with base ten blocks to use if necessary for them to represent and then compare decimal values in the tenths place and hundredths place. She reflected that she felt a sense of success when “it looked as though[t] most students were grasping the concept of tenths and hundredths” (Day 4 reflections). However, she would have liked to see her student pairs spend more time discussing their decisions for the comparison symbol used and possibly writing their thinking. She would be willing to trade off the time she used to continue the lesson from the whole class for this time. She was disappointed with the advanced group at the lack of depth of their research.

**Fourth grade implementation of unit: Mindy.** Mindy began her lesson with a 5-minute review of the story from the previous day. She asked her students to share their L50 lengths and wrote it on the board for them. She used the values given by the students to spark the discussion to introduce the lesson. Mindy asked, “What do you notice about the numbers?” (Day 3 video implementation) Like in Roxy’s class, students first answered by noticing the decimal point in the numbers. The first response was the “dot” in the numbers and when Mindy asked the students to clarify, the word decimal was uttered. Mindy pounced on the word and asked the students to elaborate on what they meant by decimal. Her students did not seem to have any background with decimals. Their responses included “11 is the size and 6 is the inch”, “5 feet and 7 inches”, and “5 inches point 7 centimeters” (Day 3 video implementation). To help them link to their prior knowledge, Mindy asked them to recall what they had learned about fractions. HR responded with, “Oh! It’s kind of like the whole
in the fraction. You have 11 whole lengths and the 6 is the fraction” (Day 3 video implementation).

Mindy then reviewed the names of the cube and the flats and then explained, “This will represent a tenth (holding the flat in her hand). So this is one tenth” (Day 3 video implementation). She then asked the class if one flat was one tenth, what would two flats and then three flats be. Finally she summarized that by adding a flat, she was adding a tenth. Then she asked the class, “If I were to represent my fish at 11.6 I would have 11 cubes and … “ (Day 3 video implementation). The students were able to say 6 flats.

Following the whole class introduction to decimals, the students were allowed time to express their L50 fish measurements with the base ten blocks while Mindy roamed the class and asked them questions to check for understanding. The teachers had one thousands cube and several flats on the table for students to use if necessary.

The students were told to draw the base ten block representations on their paper. To make drawing easier for some students, Mindy informed her students that they may use large squares to represent the cube and smaller squares to represent the flats. Students were instructed to work in teams of two or three. Mindy enjoyed listening to her students explain their representations.

Mindy was surprised to see her students understand decimals through the use of the manipulatives. She noted that when a group was struggling, she would help them see how each flat “was a layer that led to a whole” (Day 3 reflections). At the end of the class, one group was still struggling so she told them that they would tackle it together. She noted that she would have liked to allow her students more time to make sense of the problems before guiding them.
Mindy was not comfortable splitting her group into two groups. Although I spent some time talking about what Roxy had done with day 3 and raved about the success Roxy had experienced, it did not sway Mindy to separate her students. She had acknowledged during our day 3 after school collaboration session that some of her students had not yet grasped the concept of naming decimal values to the tenths, representing them with a drawing or base ten blocks, and using the representation to explain how the decimal value is a tenth.

She felt confident going into the lesson given the success of the previous day (Day 4 reflections). However, she was surprised to see her students struggle with representing and reading decimal values. She was surprised that some students called 3.7 three and seven halves and that many didn’t already know how to use a ruler.

Feeling the success from the previous day, she proceeded to have her students use Roxy’s worksheet of measuring line segments and drawing line segments of specified lengths to the nearest tenths after a short review. Her students struggled through the review, the measuring, and the drawing of line segments. There were two students who had a strong grasp of the concepts. She enjoyed seeing them help the struggling ones not only with arriving at an answer but also with the reasons for the answers. Because most of the class struggled with day 4, Mindy decided to redo day 4 at a slower pace the following day.

After looking at some of the student work during our after school collaboration session, I suggested that some of the students who she tagged as struggling may be okay in terms of conceptual understanding but may not be able to accurately subdivide their rulers into equal parts. She stated that she wants more accuracy because her class had discussed this when they were learning about fractions.
Fourth grade implementation of unit: Collaboration Session 4. During our after school collaboration session, we reviewed the events of the day and the teachers shared their successes and frustrations. At the session with Roxy and Mindy in December, Roxy shared her worksheet with Mindy and Mindy used it in February. Roxy liked the positive feedback and flexibility that the collaboration sessions allow. Mindy felt the collaboration sessions helped her prepare for the day’s lesson but she was surprised at how the students were struggling when they seemed to have done well the day before. Through the collaboration sessions and implementation Mindy has grown more confident with the instructional approach of allowing students to explore and the teacher helping the students understand through questioning.

Fourth grade implementation of unit: Roxy. Roxy and Mindy started day 5 with a review of naming decimal values and the reason behind the name. Roxy began by comparing decimals. During the previous day, Roxy had her students compare decimal values.

During the previous day’s after school collaboration session with Roxy, I noted that the reason a student used for .9 and 0.9 being equal was because they both had 9s. Roxy then used 0.9 and 0.09 for her of review of comparison between two decimal values. RO stated that 0.9 was greater than 0.09. Roxy asked RO to show the class how he knew. He immediately went for the base ten blocks at the back of the room and took what he needed (9 flats and 9 rods) to illustrate his thinking. After her review, she moved into having her students measure line segments, draw line segments of various assigned lengths, and for those who finished early, she tasked them to measure various objects of their choice to the nearest tenth of an inch. While students worked on their tasks Roxy
and I roamed to talk to students to gauge their understanding. During our after school collaboration session, we noted that we observed progress with the students. “It was interesting to see how everything that you typed in your lessons came out... I think it really helped that they used the first few days to work with decimals before they applied it to measuring” (Day 5 audio after school collaboration session). She noted, “It was easy like with CS... he was having a hard time... Just for him to make connections back to the previous lessons; that was nice. I don’t think he fully got it but at least he’s connecting. It might be easier” (Day 5 audio after school collaboration session).

**Fourth grade implementation of unit: Mindy.** Mindy veered to talking about how to use a ruler for measuring. She had her students measure line segments and draw line segments of assigned lengths.

Her day 5 was a repeat of day 4’s lesson except that she felt her students better understood how to measure. She used her review session to troubleshoot where the students had difficulty the previous day. In addition to showing her students how to use a ruler, she showed them how to divide their inch on the L50 ruler into 10 equal parts citing that she noticed many students struggling with that yesterday.

While her students were working on a worksheet similar to that of day 4 (same type of problems but segments of different lengths) Mindy and her student teacher roamed to gauge student understanding through questioning.

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³The inches on the L50 ruler from the Campaign divided the ruler into two parts only showing the halfway mark.
Mindy particularly enjoyed seeing her students completely engaged when they were either playing the game that allowed them to practice measuring line segments or were trying to solve the problematic fish. She used the problematic fish poster that Roxy had created and used on her day 4. Three groups of students who finished quickly were given the problematic fish problem while the rest of the students were given the game to play. Mindy liked that the lesson allowed students to explore the mathematics, make errors, and work together to arrive at an answer. She shared during our after school collaboration session that she felt her students needed two days to fully grasp the concepts presented in the lesson as one day. She noted that one of her students was curious about what happened if another number was added after the hundredths place. She asked the student for her thoughts. The student was able to answer with the thousandths place with a question in her voice. Mindy told her she was correct and asked her to finish her work and go out for recess.

**Fourth grade implementation of unit: Collaboration Session 5.** The after-school collaboration sessions were used for teachers and me to share their general impressions of the implementation and talk about the lesson for the next day. During these particular after school collaboration sessions and during the planning collaboration sessions some changes were made to the lesson as a result of the discussions. Roxy reminded us that she had never used base ten blocks for decimals. She felt it would be good if professional development could be provided to show others different ways base ten blocks could be used like for decimals, fractions, and regrouping.

**Fourth grade implementation of unit: Roxy.** Days 6-8 for Roxy and 6-9 for Mindy were spent closing the unit on the Size Matters Campaign. Roxy’s day
6 was spent with a review of naming decimal values, a discussion on the differences between their L50 ruler and a typical ruler, and then she instructed them to draw the L50 length of their fish according to the Campaign. They were told to draw a line segment and use it to draw their fish. Like Mindy, Roxy had to guide her students, in creating 10 parts on their L50 rulers. She was concerned that she gave them too many hints on how to subdivide their rulers. Despite all the perceived hints, she stated, “I want to go back and revisit how to represent fractions on the number line, what do we have to do? I’m surprised because of all their work with fraction bars” (Day 6 audio after school collaboration session). She used part of day 7 to address her concern. Since she had used the morning station time of day 7 for research on overfishing in Canada, Hawaii, and Japan, she allowed her students to work on creating their posters that highlighted the consequences of overfishing during their regular mathematics time. On day 8, her three groups presented their findings. From their presentations and our day 8 after school collaboration session, the teachers and I came to the conclusion that the information on overfishing on-line was too difficult for a 4th grade student to comprehend.

Roxy’s day 8 and Mindy’s day 9 was the culminating event of the unit where the students presented their findings from their research on overfishing. In Roxy’s class, her students were divided into three groups according to their mathematics ability. Each group presented their findings. From the presentation and the question and answer session afterwards, it seemed as if the students struggled to understand and summarize the facts for their poster. Despite the difficulty with the research in Roxy’s class, the students maintained a positive
disposition and reported what they could. Roxy commented that they enjoyed
the unit.

**Fourth grade implementation of unit: Mindy.** Mindy caught up to Roxy
in terms of pacing. Mindy’s day 6 began with a review of naming decimal values
and representing them using the base ten blocks. She then wrote the number 8.07
on the board and used that number to segue into the discussion of numbers to
the hundredths place. She told the class that the 7 was in the hundredths place
and asked the class to read the number. She then distributed the problematic fish
poster to each group of students. For days 6-9, Mindy had her student desks
rearranged in teams of three. Each team was instructed to read the poster and
correct Mindy’s error. It seemed as if the students understood that the
hundredths place was the place to the right of the tenths. After allowing them
some time to discuss the poster in their groups, Mindy brought the class back
together and asked the students to “Observe your rods, observe your flats,
observe your blocks. What do you notice about the rod?” (Day 6 video
implementation). Several students were able to see the pattern between the unit
cube and the rod, the rod and the flat, and the flat and the thousands cube. She
liked “seeing the eager hands of students who had their ‘aha’ moments.
Especially in connecting why these blocks were called base-ten blocks and
figuring out value of decimals” (Day 6 reflections). After the discussion, she had
her students draw the L50 length of their fish as a line segment. On day 7, the
students were given a larger sheet of paper to draw a full size sketch of their fish
with an accurate length. Mindy used day 6 for her students to draw line
segments of their fish’s L50 measurements, additionally, they could not choose
L50s that were longer than their 8.5” x 11” sheet of paper. On day 7, with the
larger sheet of paper, they were instructed to draw their fish (not a line segment representation) according to its L50 measurement. They were instructed to write the name of their fish and its L50 length. On day 8, Mindy spent about 30 minutes to review naming decimal values with individual students and review comparing decimal values with different wholes. Her strategy was to have her students put the zero after the number to the tenths place and then reason the relational symbol. Students were struggling with .02 and .20. TA said that .02 was “greater because if you add a 0 to the .02 making it .020, it’s greater” (Day 8 video implementation). A couple of kids noted that .020 is 20 thousandths. TA didn’t understand that. After the review, she distributed a fact sheet for the students to use to research overfishing. I had found these sheets after observing Roxy’s students struggle with the information they found on the internet. Mindy’s students seemed to understand the consequences of overfishing better. However, some of her students still struggled with naming decimals. On day 7, while Mindy was moving around her classroom, her interactions with nine students were recorded on video. She visited nine students who were visible on camera. Five of the students were able to name the decimal values and measure their line segments, three students could do it with assistance, and one student’s measure was not assessed by Mindy.

Mindy’s day 9 was the culminating event of the unit where the students presented their findings from their research on overfishing. In Mindy’s class, in addition to the presentations, she had her students do what she called a gallery walk. She had each group sit together and decide who (one or more students) would stay behind with the poster to field questions as groups visited their table. The rest of the team would roam and ask questions to gather information about
overfishing. Most students seemed to understand the negative impact of overfishing. They were able to answer their peers’ questions without having to refer to their poster. Mindy reflected, “I would like to reteach the entire unit, hopefully the students would get a better understanding as they ended the unit not as comfortable as I would have liked” (Day 9 reflections).

**Themes.** The research question is: what happens when teachers collaborate to implement a mathematics curriculum designed to be culturally relevant and problem-solving rich? Through the observations and reflections of the collaboration sessions and implementation of the units, three themes relevant to the research question emerged: 1) Problem-solving rich mathematics, 2) Cultural pit stops, and 3) Confidence. These themes highlight the effects of collaboration in the setting described in the methods chapter. The themes that emerged reflect the frequent instances that aided in the success, measured in teacher perceptions and growth, of the collaboration sessions.

**Problem-solving rich mathematics.** The premise behind the collaboration process was that the teachers would be engaged in planning and implementing a culturally relevant problem-solving rich mathematics curriculum. The teachers relied heavily on me to deliver the essence of the curriculum unit to them. When we met to plan the lessons, a curriculum unit was presented to them for their recommendations and consideration and study prior to implementation. All the teachers were made aware of the purpose of the study and the research question. None of the teachers raised any concerns about the lessons being based on problem-solving experiences for students. The onus was on me to ensure the lessons were problem-solving focused.
During the implementation of the lessons, three sub-themes related to problem solving arose: 1) Questioning techniques, 2) Manipulatives, and 3) Enduring understandings.

**Questioning techniques.** The ability to ask good questions of students is a mark of a teacher engaged in a problem-solving rich mathematical environment. The teachers in this study were well aware of the important role questions play in a problem approach to curriculum. The lesson plans included suggested questions to aid students in gaining understanding and to push student thinking to the higher levels. The different teachers exhibited various levels of skill and comfort at asking their students questions. All four teachers regularly asked questions to check comprehension and to push student thinking. My observations of Heidi showed that she asked questions to push student thinking beyond the objectives of the lesson. Whether in a whole class, small group, or individual setting, Heidi could be heard asking, “What happens if...” During our collaboration sessions, she would share that she would ask questions to see how far she could push their thinking. During the day 4 collaboration session, when referring to the lesson where Heidi had her students measuring objects with paperclips to find objects of a specified length, Heidi said, “That’s why I tried 30, just for fun. I wanted to see if their thinking was still the same from this morning” (Day 4 audio after school collaboration session). She wanted to see if the students could identify an object in the room – and not in their bin – that was 30 paperclips in length. Some students knew that the object had to be larger than the objects in their bin. This type of questioning was typically observed in her class. An opportunity to push thinking beyond the objective presented itself on day 5 in Mindy’s class when a student asked her a question that pushed her own
thinking. Mindy responded with, “What do you think?” waited for an answer and then told the student to finish her work and go out for recess (Day 5 audio after school collaboration session).

Tara exhibited the most apprehension about the questioning of students. She often asked me if she was asking the “right” questions and she often worried if she asked all the questions indicated on the lesson plan. Through observing her video recordings, the kinds of questions she asked targeted gaining student understanding. Despite assurances that her questioning was fine, she revealed in her interview:

Since it was your (researcher) lesson, I had to think about what questions to ask. I ended up having a BEFORE, DURING, and AFTER cheat sheet of questions to help me remember. I had the sheet in front of me to help me remember the questions and how to teach the lesson. (Interview)

From as early on as July, 6 months prior to implementation, Tara expressed reservations and frustrations about the unit. As a self-proclaimed “drill and kill” (Interview notes) type of instructor, the lack of time for worksheet practice in the unit was a source of concern that Tara was not shy to express however, she resigned herself to trying the lessons at face value. At the end of the implementation, she reflected that she would encourage others to participate in this type of project because it is a good opportunity for teachers to collaborate, learn from each other, and learn how to not only teach the unit but how to question students. This is important because their answers can show the teacher what their level of understanding is. Both aspects of teaching/learning are important: getting the answer and being able to explain thinking. (Day 5 reflections)
The collaboration process developed her questioning skills and led her to see the value of asking probing questions. Her continual quest to know if she’s asking the “right” questions indicate a sense that she believed questioning was a valuable tool in teaching. And in the end, she achieved a new outlook on teaching.

Roxy seemed to be a natural at the questioning technique. Her preferred method of assessing student understanding was through questioning, “I think LO and CA are still struggling but the rest are getting it. I want to sit down with them and help them” (Day 4 audio after school collaboration session). Each day of the lesson implementation, Roxy reflected that she enjoyed it most when the students were engaged, when they were reasoning, when they were justifying their thoughts when she asked questions, and when she could help struggling students. To achieve these desired results, good questioning techniques were essential and Roxy seemed to comprehend this. The only challenge Roxy faced with her questioning was ensuring that she asked all the questions that were in the lessons. She shared that she would have to refer to the plan to be sure she asked all the questions or if she caught herself missing a question, she made a note to ask it the next day.

Mindy was regularly observed asking her students questions. She never mentioned questioning as being problematic for her. She noted that watching Roxy on tape before implementation helped her tremendously. The questions she asked were similar if not identical to Roxy’s. Mindy often expressed confusion when her students would seem to understand the concepts during her whole class question and answer sessions but when she collected their reflection sheets, she would see they actually didn’t understand the material. Although her
questions mimicked Roxy’s, they often lacked the wait time necessary for students to think and respond. She could often be heard giving the students the answer she wants or asking an either or question as follow up to help the student along. She remarked that if she didn’t give answers, the lesson would take too long. It seems as if her students are accustomed to Mindy giving away much information thereby allowing them to sit and wait for her to think for them. For example, on day 3, she focused on the representation of the decimal value without attending to the why behind it. “Mindy: What does 7 and 6 tenths look like, using your cubes and flats? JS: 7 cubes and 6 flats” (Day 3 video implementation) without asking JS why. On day 3, when she introduced decimal values to the tenths place, the video revealed that her students had a fraction base and that at least one student understood the connection between fractions and decimals. As you’ll read in the exchange below, HR made that connection. Instead of just asking the class if they understood HR’s epiphany, she could have made a more lasting impression on her students if she asked HR to elaborate and used his words to link to the base ten blocks as a visual for the fraction connection.

HR: Oh! It’s kind of like the whole in the fraction. You have 11 whole lengths and the 6 is the fraction.

Mindy: Do you understand what he’s saying? If I were to say this it would be 11 and 6 tenths.

Student G: Oh!!! I get that.

Mindy: Are we connecting?

Students: Connecting!
Mindy: Decimal is like the same thing as a fraction. So 11 is the whole and... This will represent a tenth. So this is one tenth. So this would be 1 and 1 tenth. If I were to take another one (she grabbed another flat), what would it be?

As Mindy visited students on this same day, she tried to help them understand why the tenths are called the tenths.

To give you guys a better visual, let’s use this whole. You notice that it’s about the same as the flat except that there are layers (she held the flat next to the top of the cube), right? How many layers of flats will make this whole cube? (Day 3 video implementation).

The visual she used for that group would have been nice to use with her whole class. During our after school collaboration session on day 3 I had shared that I liked how she showed the group in the dialogue above where the tenths were coming from. The following day, she showed the entire class. Before having them see that 10 flats equal the whole (cube), she wanted to see if they understood that already by asking, “How did we get the 6 tenths?” (Day 4 video implementation).

The responses indicated most students did not already understand this. Responses included, “6 flats, from the 5 flats, minused it together, from the ten tenths, and from the inch” (Day 4 video implementation). The students who referred to the flats may have meant that 6 flats represented 6 tenths but Mindy responded to the flats responses by telling her students that flats is a term they use in class and they need to explain what they mean as if they were explaining it to their mother. No one was able to explain.

Mindy: Where did the 6 tenths come from?

Student G: It’s part of the whole.
Student H: It’s a whole number.

Student I: No. A whole number is 10 inch.

Mindy: If I have 6 tenths here, how many more tenths do I need to make a whole?

She left the idea of naming decimals and understanding the logic behind the name and continued unto the discussion of line segments that later led to measuring and drawing line segments of a specified length. During our after school collaboration session, Mindy indicated that her students did not understand the connection between the base ten block representations and measuring line segments using the L50 ruler (recall that the L50 ruler is only marked at the halfway mark so that students could mark it in tenths). Student struggle as they measured using the L50 ruler was anticipated. However, with the lack of understanding of decimal values using base ten blocks (as evidenced in the types of responses in class and on their reflection sheets), difficulty making the connections between the base ten blocks and measuring with the L50 rulers should not come as a surprise. In Roxy’s class, by the time they were measuring their line segments on day 5, some of her students struggled at first but with questions linking back to the base ten block representations and their prior knowledge of fractions, the students were able to measure and draw line segments to the nearest tenth of an inch.

Mindy knows and appreciates the value of asking good questions. From her reflections, Mindy shared that her favorite parts of the lessons include when students are engaged, gain understanding, and are able to show her ways to represent the decimal values. Through good questioning, she can consistently attain these desired results. During our after school collaboration session on day
3, when she first introduced decimal notation, reading, and rationale, I had shared that I felt she gave the students too much information and didn’t allow them much time to respond, “Just for the future… if there’s an opportunity for them to explain, that’s always better” (Day 3 audio after school collaboration session). She didn’t say much to this but agreed. Mindy’s good questions have potential to allow for more insight with more opportunities for her to experience good questioning situations.

Each of the four teachers appreciated the results that ensued from asking good questions. Many reflection responses indicated that they enjoyed it most when they could hear their students justify their thoughts. This ability to justify thoughts orally is a direct result of the consistent practice students obtain through the questioning process that occurs in a classroom. Although each teacher was at a different stage of the questioning process (either perceived or actual), the fact that they appreciated the results implied that they were willing to continue teaching through questioning.

Manipulatives. The effective use of manipulatives in mathematics classes for exploration and representations can be a powerful tool for promoting a problem-solving rich classroom. The 4th grade teachers unit revolved around the context (Size Matters Campaign) and the use of the manipulatives (base-ten blocks) to engage the students in the mathematics. The 1st grade teachers did not use any commercial manipulatives. Pattern blocks, base-ten blocks, linker cubes, and other commercial manipulatives were not used in their lessons. The mathematical objective of the unit was for students to learn how to linearly measure using non-standard units. One could consider the use of a variety of
non-standard units as manipulatives. As such, I will treat each case, the 4th grade case and the 1st grade case, separately.

Both 4th grade teachers found the use of the base-ten blocks to be surprisingly effective:

This was the first time I used base ten blocks to teach about decimals. Last year I used money to teach decimals. I think students this time were making better connections with the concept when asked to think about the construction of the whole as a fraction. (Day 4 reflections, Roxy)

I was hesitant about whether or not they would grasp onto the concept of decimals. But with the help of the base ten blocks, they were able to better understand it. I did have a few students who still weren’t able to get it, but one group I had worked with showing them how each flat was a layer that led to a whole…then it made sense to them and they were able to help each other. (Day 3 reflections, Mindy)

Prior experience and philosophical beliefs about the use of manipulatives in a mathematics classroom affected the way in which the base-ten blocks were used. Roxy had indicated that she had used manipulatives in other mathematics lessons such as when she had her students explore fractions. She shared that she liked to start with the use of manipulatives as a way for students to explore concepts but eventually wean them off the manipulatives for them to be able handle the mathematics abstractly. With the base-ten blocks, she was able to use it to introduce the idea of tenths, let her students explore with the blocks, have her students use the base-ten blocks cut-outs to represent the decimal values and use their representations as a tool to explain their thinking, and give her students something to anchor to whenever difficulty or a challenge was presented to them.
(like with problematic fish). Roxy was thoroughly impressed with the impact the base-ten blocks and the base-ten block cut outs had on her students. The freedom to be able to represent and make-sense out of decimal values with the base-ten blocks and their prior knowledge with fractions opened doors of understanding for many of her students. Students who struggled were able to use the base-ten blocks as necessary. A student who Roxy identified as one who struggled in math showed no indication of her struggling self during these lessons.

Roxy revealed that the next time she uses the lessons she would use the base-ten blocks more, “I think they would have made better connections to decimals and fractions using the concrete manipulatives versus the paper printouts of the base ten blocks” (Day 3 reflections). “I have used manipulatives with my students before, but I did not want them handling the blocks during the whole group discussion to prevent distractions from the learning objective” (Day 3 reflections). I suggested that she set aside time at the beginning of the school year to let the students explore the various mathematics manipulatives to remove some of the distraction from the learning objectives when she needed to use them later in the year. She commented that she always lets her students explore the scientific tools that she has but never thought about doing the same with her mathematics manipulatives. On day 5 of our after school collaboration session, Roxy recommended, “I think you should do a workshop on different ways to use manipulatives. I know that a lot of teachers use it for number sense. But I know some teachers are not comfortable with the regrouping… just to show…”

Mindy commented that the use of manipulatives was more of a reward for her students who understand the mathematics (Day 2 after school collaboration
session). She reflected that she typically doesn’t do “fun stuff” (Day 2 after school collaboration session) in class because of time constraints. However, she enjoyed seeing her students engaged and having fun. She never explicitly expressed being at odds with the lessons because of the use of manipulatives but her decisions to resort to direct instruction (almost every other day of the unit) in an attempt to move the lesson along implied a level of discomfort with the effectiveness of manipulatives as a tool for aiding in student understanding.

After each direct instruction day, she felt her students understood the concepts better but when posed with questions that required explanations during the exploration time immediately after the direct instruction or the next day, she would express frustration because her students didn’t understand like they did the day before.

However, her willingness to try and desire to use the unit again the following school year because “it is a very interesting and fun unit that is related to our island’s needs” (Final reflections) indicated an implicit acceptance of the use of the base-ten blocks. Although she used a lot of direct instruction, she found herself constantly referring to the base-ten blocks whenever her students showed signs of struggle when she visited them on the floor. With Mindy’s limited experience and philosophy on the use of manipulatives, “We are usually into powerpoint [sic] lesson, practice, and then assessment… miss working with lessons like these” (Day 1 reflections), her statement of intent to use the lessons again next year indicate some change in her philosophy that manipulatives are not worth exploring because of time constraints. She seems to be more open to allowing time for the use of manipulatives as tools for exploring mathematical
concepts. She noted in her interview that her students enjoyed the activities in this unit because it was out of their normal math routine.

Heidi and Tara did not use mathematics commercial manipulatives. Since their learning objective was on measuring with non-standard units, one could consider the non-standard units as manipulatives. The students used the various non-standard units – coconuts, leaves, sticks, paperclips, and teddy bears – to measure their height and the lengths of objects in their classroom. By being allowed to explore lengths with a variety of non-standard units, students were able to begin to understand measurement as a function of the unit used.

Both Tara and Heidi used manipulatives regularly in their classes. Each class had tubs of a variety of manipulatives for various uses. Typically, I borrow a set of Tara’s linker cubes every year for a mathematics lesson I do with my students. Each year, when I ask for the linker cubes, Tara tells me that she has to go back to her lesson plans to be sure she wouldn’t need them during the time I would need them further indicating her regular use of manipulatives. Since we know that Tara’s lessons are written by Heidi, we can conclude that Heidi too uses manipulatives regularly. During the course of our meetings, I had never encountered Tara or Heidi expressing discomfort in using manipulatives. This leads me to believe that they do not find the use of manipulatives to be too time consuming for use. Although Tara had expressed that she is more of a “drill and kill” type of mathematics instructor (Interview), she never expressed reservations about the use of manipulatives.

When I first wrote the unit, I had intended for the five days of lessons to give students a chance to understand iterations in measurement. Through the implementation of the first grade teachers, I understood the unit to be more than...
that. I realized I wanted it to give students a chance to understand measurement as a function of the unit used through the iterations of the various non-standard units. Although I was unable to convey this to the teachers so succinctly at the time, I will be able to update the objectives of the lessons in the unit and share my findings with them as they prepare to teach another group of students the same lesson.

When we had discussed day 5, I had suggested that we steer the lesson to having the kids explore the idea of measurement as a function of the unit by having the kids measure the same objects they had measured in day 3 or day 4 but using a different unit and having them discuss why the same object has two different measurements, “Heidi: Maybe the kids will make the link back to the story! Tara: I want to try that!” (Day 4 after school collaboration session). The teachers were eager to see how well the students understood measurement.

From day 1, the students in both classes were introduced to the idea of iterating with a variety of units through the story of Jose (Miura, 2009). The story began the journey of measurement for the 1st grade students. The teachers were able to talk to the students about the different units that were used to measure Jose’s height and use that as a springboard for the measurement of their heights. The following day, the students ventured outside of their classrooms to use the materials found on their campus. Through their exploration of measuring their heights and with the help of their teachers guiding their experience, the students were able to understand that linear measurement through iteration required attendance to spacing between units, cognizance that the same unit be used for each iteration, orientation of the same unit be the same for each iteration, and that the units being iterated be collinear. With about 3 days of practice, almost
every student in the class seemed to understand the requirements for iterating correctly. The chance to use the different non-standard units in different settings was pivotal to their understanding of iterating. The non-standard units as manipulatives allowed for the exploration of linear measurement and the teachers were able to use their explorations, as the students were measuring, to talk about the different requirements for iterating correctly.

Heidi had the same sense that by the end of day 3, almost all her students could iterate correctly. In the morning of day 4, she had her students finish measuring the lengths of their hands and each child shared his hand length with the class. After several students shared their hand lengths, they were aware of the typical hand length of a first grade student. When CN presented his hand length outside the range of what had been presented, IN challenged CN telling him that his measurement was not possible (Day 4 after school collaboration session). This gave Heidi confidence that her students might be able to estimate different lengths using the paperclips as their unit of measurement in the afternoon. Her students abstracted the paperclip by imagining what four of them lined up would look like and hunted for objects in a tub that would be that length. Heidi encouraged her students to check their estimations by using the paperclips she put in a pile in a designated area. She wanted to change the role of the manipulative, in that instance, from one for exploration to one as a tool. Her students had no trouble deciding to use the paperclips to check their estimations when they were ready.

On day 5, both teachers tried the lesson to see how deeply their students understood measurement. Towards the end of Tara’s class, Tara shared that HN “held [the linker cube] up and said, ‘Because the paperclip is bigger and the
linker cube is smaller and that’s why they’re different.’ They didn’t have the vocabulary to say, ‘It’s the unit of measurement’” (Day 5 after school collaboration session). Tara indicated that this was the best part of her lesson that day (Day 5 reflections). She piped in that she would continue her lesson the following week with the way Heidi conducted her day 5 afternoon lesson. “Tara: I didn’t do that. I can do it Monday, I mean Tuesday. I can try that” (Day 5 after school collaboration session). Her student’s ability to use the manipulatives to justify the reason for the different measurement values, without having the language to express it, reveals a very powerful tool for justification at the early stages of learning. Without the manipulatives, HN may not have been able to express her thoughts.

Heidi’s day 5 lesson began in the morning. She was eager to see if the students “could make that connection [between measurement and the unit used] in the afternoon” (Day 5 after school collaboration session). During her short morning session they went through different examples of units and [the students] started saying units that were in the tub. I was thinking, ‘Are they thinking that the objects are units or are they thinking that the objects can be used as units?’ I wasn’t sure. Eventually… they were talking about them as units because somebody said soil and another student said it’s too small so I could see that they were talking about the objects as units. I gave an example and asked, ‘Can I use my eraser as a unit?’ They said yes.” (Day 5 after school collaboration session)

She felt that they would be able to make the connection but when the afternoon arrived, the students were not able to see the link between measurement and the
unit being used. In her afternoon lesson, her students measured a mirror with paperclips and saw that it was 4 units long. She measured then measured the same mirror with the teddy bears and got 7 units. She asked them to vote on whether they believed that 4 units, 7 units, or both measures was the right answer. Most students voted for 4 units because they measured it themselves. Heidi reviewed the story and her students all concluded that all the measurements of Jose’s height were correct. She polled the students again asking for the correct mirror measurement. One less student voted for both. Despite the review, the students weren’t able to make the connection between Jose’s heights and the mirror’s lengths. It may have been more fruitful to allow her students to measure more objects with the teddy bears as the primary activity of the lesson and then end with the mirror for the whole class. Although it is clear that her students have gained much insight into linear measurement, they still need to be able to manipulate other non-standard units as a way for them to make the connection Heidi was aiming for them to attain. This is especially true when one considers that the students’ reason for not picking 7 units or both is because they didn’t measure it themselves. Heidi recognized that her students needed more practice and would revisit the day 5 lesson the following week.

All four teachers recognize the power of the use of manipulatives for exploration and then as a tool to represent mathematical ideas such as measurement and decimal values to the tenths and hundredths place as a vehicle for discourse. In both instances, the use of manipulatives in a mathematics classroom can give strength to a lesson’s ability to produce enduring understandings.
Enduring understandings. The Common Core standards in mathematics emphasizes that through the mathematical practices, enduring understandings can occur. Three teachers from this study successfully used the lessons and revealed instances of the mathematical practices that led to enduring understandings of the objectives.

What really surprised me and made me happy… not to label the kids but it’s not always the smart ones that get it. It went across the class. Knowing that a lot of kids were struggling, not only in math but in reading – they caught the idea of what measurement is about. I was pleased with that.

(Day 5 audio after school collaboration session)

One teacher, Mindy, revealed that the framework of the lesson was completely different from what she normally does. She tried the lesson, as written and included some direct instruction when she felt her students were not grasping the concepts. Using direct instruction as a way to remediate did not prove to be very effective. After 9 days of instruction, based on her student reflections, she felt that most students did not gain enduring understandings. However, she did not fault the lessons as she indicated that she would re-teach the entire set of lessons the next week.

On day 1, Heidi made a remark about how surprised she was that her students were giving her preposterous heights like 8 feet as a measure of their height because earlier in the year she noted that her class had talked about a newspaper article that spoke of giant squid that was found. She shared that they measured the length of the squid (about 9 feet) on her floor and her students were amazed at its size. She couldn’t believe that after that experience, they weren’t able to connect and realize that they couldn’t be 8 feet tall. This reveals
that one experience with measurement is not enough to create an enduring understanding. In fact, as the week came to an end, we talked about times throughout the remainder of the year where measurement and the ideas learned from the unit could resurface. I shared that when they learn about pictographs, they could connect to the idea of iterating as the students learn to stack objects to reveal quantities. A week of intensive exploration and discussion about measurement was fruitful and necessary. It allowed students to explore the mathematical concept through a variety of experiences. However, it was not enough to get all students to see a measure is a function of the unit used. If students are allowed a chance to connect the ideas from the week to other mathematics lessons or other subjects, the understanding will endure.

In addition to allowing time for connecting to other mathematics lessons or other subjects throughout the school year and exposing students to a variety of learning experiences, prior knowledge can aid in the speed and depth at which enduring understandings can occur. In Tara’s class, HN was the student that surprised Tara on day 1 with HN’s existing knowledge of measurement. HN knew about spring scales in supermarkets and that pounds were shown on the device. Heidi shared that her knowledge was probably a result of her HN’s mom working at a store and that HN likely spent most of her time at the store with her mom. At the end of day 5, it was HN who was able to explain that the size of the unit affects the measurement. In Roxy’s class, the fact that her students displayed an understanding of fractions aided them as they grappled with decimal values. This link that Roxy explicitly made for them not only allowed them to use the link to help push their thinking forward with decimals but also gave them an opportunity to create an enduring understanding with fractions.
All teachers expressed joy in seeing their students justify and explain their thinking. After Tara shared the moment in her class when HN realized that the size of the units effected the measurement but that she “didn’t have the vocabulary to say, ‘It’s the unit of measurement!’” (Day 5 audio after school collaboration session), Heidi interjected by sharing that her students could express it when they are ready:

> Because we practice the language... it starts from the door... like AO can spell that word [iterate]. Almost all of them can read the word. They’re using the word *unit, measurement, even iterate*. They’re using the language. They’re very comfortable... they can explain better when they use it. (Day 5 after school collaboration)

Heidi’s comment caused Tara to reflect and decide that she wants to use the language more in future lessons, “I found out from conversations/collaboration with [Heidi] that maybe I need to use the vocabulary more often throughout the day and have the students able to explain the definition and use the word in sentences” (Day 5 reflections). Roxy also mentioned the use of the language as a source of frustration at times, on her part. She shared that she was not accustomed to using the words flats and rods for the base-ten blocks. However, as the lessons developed throughout the 8-day period, she understood the necessity for that language because of what the manipulatives represented. She appreciated how her students were able to explain their thoughts using the language.

Enduring understandings emerged when students were exposed to a variety of learning experiences, when students were allowed time to continue their journey of understanding through connections to other subjects or other
mathematics topics, when students were assisted in activating their prior knowledge, and when students were encouraged to use the language required for the objectives. All these conditions supporting enduring understandings were met when the teachers implemented the lessons that I framed with the Common Core mathematical practices. Evidence of the teachers’, including Mindy, cognizance of this can be found throughout the collaboration and implementation process. The next eight paragraphs illustrate an example of this cognizance in each of the eight mathematical practices.

Tara realized as she watched the video that what she deemed as misbehavior was students trying to make sense of the measurements. She noted that she thought JSH was playing around but upon inspection of the video, he was actually using his thumb to try to figure out the estimation (Day 4 reflections). Her realization that her students were actually trying to make sense of the concepts instead of playing around helped ease her level of discomfort in the classroom.

Mindy and Roxy revealed that they value student reasoning. Mindy enjoyed seeing her students help the struggling ones not only with arriving at an answer but also with the reasons for the answers. Each day of the lesson implementation, Roxy reflected that she enjoyed it most when the students were engaged, when they were reasoning, when they were justifying their thoughts when she asked questions, and when she could help struggling students.

Students weren’t only reasoning to make sense of problems but they were also critiquing their peer’s thoughts in small group and whole class settings. On day 1 in Heidi’s class a student kept calling out and finally was called on by Heidi to state that he felt 8 feet was really tall and couldn’t be a student height.
All teachers allowed their students to model the concepts through the use of manipulatives. This was evident throughout both cases. When teachers visited with small groups, conversations often revolved around the representation of the mathematical concept. The first grade teachers frequently manipulated the non-standard units to get students to correct them and show them how to measure properly.

As early as day 1, Tara’s and Heidi’s students were deciding on which manipulative to use as a tool for measuring their height. Giving the students this decision allowed Tara and Heidi to discuss the rationale for their decisions with each group. During a after school collaboration session, we had discussed the possibility of assigning units to the students. The teachers were concerned that students may choose a unit that is too small, like pine cones. “If they used pine cones, they most likely won’t finish when time is called and they’ll be disappointed. But that could be part of the conversation with the students” (Day 1 audio after school collaboration session). The conversation ended with Heidi realizing that allowing students to make mistakes could present some powerful conversations about the concept. When Tara’s student HN used the linker cubes and the paperclips as tools to help her explain her thinking, the manipulatives were not given to her, she looked for them to use.

During implementation, issues of precision arose in both cases. In grade 1, we had discussed, at length, the need for students to be precise about their linear measurement. We had discussed that if a 1st grade student knows to say a little more than the nearest whole unit, then that would be sufficient for precision. Because the unit started with the story (Miura, 2009) that used a half unit in one of the measurements, the students in both classes were inclined to say and a half
for every measurement that had a little more than the nearest whole unit. This
opened discussion for number sense and ensuring students understood that the
half was after the nearest whole unit. In grade 4 Roxy had tried to have her
students accurately measure their fish to the nearest tenth of an inch but because
of typical inch rulers are not separated into tenths, this proved to be difficult. We
discussed this expectation of hers during our after school collaboration session
and concluded that it wasn’t fair to the students to expect them to measure
accurately without the proper tool.

The opportunity for pattern thinking primarily emerged in grade 4 when
students were given the challenge of the problematic fish. They were to use what
they understood about the tenths place and see if they could represent a value to
the hundredths place by recognizing the pattern the base-ten blocks use for
organization. Mindy noted that she gave two groups of students the problematic
fish the day before the whole class discussion, “They were very much involved
in trying to come up with a solution for everything” (Day 5, reflections). Mindy
used whole class discussion and the pattern of the words in place-value to help
the rest of the students see the connection. She asked her students if they knew
how to read 8.07. When a student said eight and seven tenths, she brought their
attention to the zero and had them try again. HR said, “8 point 7 hundredths”
(Day 6 video implementation). She repeated what he said with 8 and 7
hundredths and asked HR how he arrived at hundredths. He responded,
“Because the hundredths are after the tenths” (Day 6 video implementation).
After getting the pulse of the class on his statement, she wrote 8.07 on the board
and identified each place-value for the students. Roxy also presented the
problematic fish with the whole class. The students struggled to see the pattern.
Roxy was surprised at “how easily students were able to explain how the flats represented a tenth of the whole, but how difficult it was for many of them to see how the rods represented a hundredth of the whole” (Day 4, reflections).

The teachers in grade 4 saw an opportunity to connect their students’ prior knowledge of fractions as a tool for helping them understand decimal values. The teachers realized that fractions and decimals are of a similar nature. They knew that students could start to think of generalizations made from fractions and consider if the same generalizations can be applied in the new situation. In Roxy’s class, this was especially apparent. “Roxy: So why would you use 5 flats? GL: It’s half of 10. Roxy: Half of the… KI: Whole” (Day 3 video implementation). It seemed as if HR in Mindy’s class could have said more about the connection he was making with fractions but in a whole class setting, Mindy decided to summarize his epiphany and move the class forward with her written number and the identification of the place-values as a way for her students to know the different place-values.

All teachers were concerned about enduring understandings. This was expressed through their daily reflections and whenever we met for our after school collaboration sessions. Whenever it seemed like a large portion of the class did not understand the concepts, the teachers responded to the situation in different ways. Mindy responded with a lesson more familiar to her style: direct instruction. Roxy responded by separating her class into two groups: the blue group (those that she felt understood the concept) and the green & red (those who were struggling) group. Roxy worked with the struggling students while the blue group was left with the principal in her classroom to begin their research on overfishing and then to start work on measuring and drawing line
segments of assigned lengths. The first grade team shared that a pattern of teaching worked particularly well for them: “talking, work, talking, work, and review” (Day 5 audio collaboration session). I share their sentiment and noticed that heavy talking, as Tara put it, may not be a very effective use of time for enduring understandings.

In Heidi’s class, I wondered about the necessity of drilling the concept of iterations into the students prior to their outdoor activity. When the students exited the class, with their plans, Heidi and Tara felt that there were issues with the experience. I think that if less time had been allotted for the drilling of iteration prior to going out and the lesson included a time to return to the class for reflection and refinement then another excursion outside, the lesson would have been better. This idea, after day 1, was put into play. On day 2, had her students reflect and refine the same day after I left their class. On subsequent days, she used her morning business time to reflect and refine, if necessary. Tara used our after school collaboration time to learn what Heidi did differently and try it out herself. Often, she would call her class together on the carpet for reflection and then have them try the activity again or in a different manner, sometimes more similar to what Heidi had done the previous day. The first grade teachers, because they had the opportunity to collaborate as a team, were afforded this luxury.

Enduring understandings impacted these four teachers. It caused them to be more cognizant of their teaching and how it affected their students. It caused them to want to ask good questions, to want to use manipulatives more effectively, and to want to witness growth more immediately through student reasoning, “if they were able to support their thinking it is a better indicator of
mastery versus paper and pencil” (Grade 1 teachers, Interview). In the end, two teachers shared their thoughts on the bearing the unit had on their students.

Heidi shared:

I really didn’t think they’d go that far. I’m very pleased with the growth in just one week. Normally I go two weeks with something like that. With just one week, with what they’ve learned so far, they’re not all at mastery level, but I’m very pleased with the turnout. (Day 5 after school collaboration session)

Roxy shared:

Overall, they were really excited about the lesson – or the visitor (referring to my presence in the room). At the end of the day, I do a reflection asking them what they learned and a lot of the students reflected on math as opposed to other subjects. (Interview)

*Cultural pit stops.* A Cultural pit stop is the term I have used to indicate whenever a cultural connection was made to the lesson whether intentionally written by me or whether interjected by the teacher as a way to make the context meaningful. Because the units were designed to be culturally relevant, what impact, if any did cultural pit stops have on the collaboration process and the implementation process?

The context of the units revolved around an aspect of the Chamorro culture in the Commonwealth of the Northern Mariana Islands (CNMI). For grade 1, that context was the story (Miura, 2009) and in grade 4, it was the Size Matters Campaign with a story (Miura, 2011) that accompanied it.

In grade 1, cultural pit stops were limited to the story (Miura, 2009) and to their adventure outside the next day to measure their heights using nature’s non-
standard units. In the story, many opportunities to talk about the culture emerged. Heidi used every occasion for a cultural pit stop to pause and explain a bit about the culture to the students. Whenever possible, she linked some of the cultural practices of the Chamorros to the other ethnicities in the class. However, Tara stated that she did no such thing because she assumed that since the students were from the island, they would already understand the cultural nuances of the story. Recall that Heidi is Chamorro who “value[s] it [the Chamorro culture and language] highly because in a lot of ways it defines who I am” (Background information). Tara on the other hand is not from the islands. She moved to islands over 20 years ago, “I would still have a hard time [making cultural connections] because I’m not from here” (Interview). She questioned whether students using their natural environment was really utilizing the culture: “I can go outside and use leaves... but am I really using the local culture or is it just outside?” (Interview)

Despite their cultural background differences, the two teachers never found the opportunity to talk about the culture during the after school collaboration sessions nor to mention the culture in their reflections. The only time cultural pit stops were rampant was during the story (Miura, 2009) in Heidi’s class and when she reviewed the story the following day. Heidi melded the ideas of the story with the mathematics. Her weaving the two components together gave the students the context necessary to learn the mathematics. As she revealed in our collaboration session, she found herself (as did Tara) referring to the story often as a method to help the students with the mathematics. The teachers used the mathematical ideas of the story but never referred to any of its cultural aspects. However, at the end of the week Heidi shared:
I think that's important to see that there's math in culture. I think we need to encourage it. It's not always easy to see. It would be nice for someone to come up with more lessons. My husband and I are very interested in how the ancient Chamorros developed their tools (especially the latte stones). If people saw that, they would appreciate it even more. If they saw the intelligence behind it. (Interview)

Tara shared that mixing culture and math “makes math more interesting. The more it's done in the classroom, more connections, make math more real” (Interview).

The 4th grade classes had more opportunities for cultural pit stops throughout the lessons. As soon as the story (Miura, 2011) and the connection to the Size Matters Campaign were introduced, the mathematics began. The students were presented with a real issue on the islands: the prevention of overfishing. Every lesson, every day, a connection to the Campaign was made although the focus of the lessons remained mathematical.

Like Heidi, Roxy is a Chamorro, “I was raised with many teachings of the traditions, customs, and beliefs of the Chamorro culture” (Background information). She prepared her students for the story (Miura, 2011). She asked them if they had any relatives who fish or if they had gone fishing themselves. Many students became excited and started sharing their stories with their teammates.

Mindy is not Chamorro but considers herself a Pacific Islander, “a local” (Background information). She did not prepare her students the way Roxy did. However, I don’t believe that their cultural background was the reason for the
difference in the way they prepared the students for the story. I believe that their approach to teaching differs because Roxy believed:

I don't know if it's culturally but I always try to connect it back to real life – back to what they experience. With fractions, pizza, parties, salads. When we practice just a skill it's harder for them to make a connection without teacher guidance. Students are less interested when the connection is not made. When they don't understand why they are doing something... (Interview)

Whereas Mindy indicated that whenever she read a story to her class, she didn’t typically stop and ask questions until the end, “So it’ll be a run through and then a recall. I was thinking with the pictures, they would be able to recall” (Day 2 audio after school collaboration session).

Both 4th grade teachers practiced reading the Chamorro phrases in the story prior to their reading. And both teachers did not feel confident with their reading of the phrases. They both attempted to read the first phrase then resorted to other options. Mindy used the English translations provided in the book and Roxy asked me to read the phrases for her. Mindy was not bothered by her inability to read the rest of the Chamorro phrases, “I only read the first sentence and then after that, I couldn’t. It was too small for me to read. I had practiced at home. When it came up to the screen I couldn’t see it…” (Day 2 audio after school collaboration session). Roxy, however, spent a good portion of her day 1 reflection talking about ways she would change the way the reading transpired. She considered pre-recording her reading or providing books (the story was projected and read to the class) for each student or student pair so that they could assist in the reading.
Both teachers did not encourage the use of the Chamorro names of the fish indicated on the Campaign. When asked, Mindy found no need to use the names because she didn’t know how to pronounce many of the names. Roxy responded with surprise. She said that she didn’t realize that she should have used the Chamorro fish names. I told her that it was the fault of the lesson for not being explicit about trying to use the Chamorro fish names.

Roxy found great value in connecting culture and mathematics. She noted that the non-local kids aren’t really interested in the Chamorro/Carolinian Language and Heritage Studies (CCLHS) class (Interview) and she suggested that having cultural connections in class might increase interest in the CCLHS class. She noted that connecting culture to other subjects would be valuable.

I want to put more time and effort to really look at creating units that reflect our culture... not just for math, but for other subjects like Language Arts and stories – connecting a story to a local novel or a legend... It’s worthwhile. (Interview)

Mindy also found value in connecting culture and mathematics, “I like it because it’s related to this place. I think that outside of the classroom, students will be able to share with relatives and apply it in the future or in the present” (Interview).

The teachers who were Chamorro showed the most enthusiasm during the reading of the story and for grade 4, connecting to the Size Matters Campaign. However, all teachers showed different levels of appreciation for the culture being linked to the unit.

Confidence. As the teachers embarked upon their journey with the culturally-relevant problem-solving mathematical units, they each began with a
different level of confidence in their ability to implement my lesson. However, as
the implementation days passed, growth in confidence resulted. This growth led
to change in all four teachers.

From the beginning, Heidi and Roxy appeared to be the most confident
among the four teachers. Heidi was always eager to share her thoughts during
all the collaboration sessions. She was never shy to ask questions. During the
implementation of the lessons, she expressed confidence from beginning to end,
“I feel confident, although I made silly mistakes. Overall I feel very comfortable”
(Day 5 reflections). Roxy’s confidence was a quieter one. She often reflected and
observed before speaking. Like Heidi, she did not hesitate to ask for clarification
or share her thoughts, especially when asked. She was always steadfast in her
desire to ensure that learning occurred with her students and every question and
comment she made reflected that:

When you say “What do you think .6 of an inch looks like?” Are we
talking about the blocks? Right here, we’re going to draw line segments
but that was their independent work so… I still haven’t brought them
back and said, “OK, we’ve been talking about decimals…” This one, bring
the focus back to the inch, what does .6 of an inch look like. They’ll
respond with the blocks. Then we ask what does an actual inch look like?
Do we want them to look at a ruler?... The L50 ruler. (Day 4 after school
collaboration session)

Roxy indicated once that she didn’t feel completely confident with a part of the
lesson:

The only part of today’s lesson that I did not feel total confidence with was
to continually use the language of flats and rods and to not get them
confused when speaking of the tenths and hundredths versus the tens and hundreds. (Day 4 reflections)

She was aware of this issue earlier and had started having her students practice the language. Her indication of wanting to use the lesson again next year prompts me to believe she will be more cognizant of the use of the language and begin emphasizing it during her number sense lessons. She approaches teaching and learning with a vision, “Yes, it’s important for them to know strategies but they also need to know the concept – how are they being taught from 1st through 4th?” (Pre-implementation audio collaboration session). Because she values that some sort of unity occur from grades 1 through 4, it would follow that in her class, she would ensure continuity and consistency of the use of language.

Tara and Mindy did not exhibit the same type of confidence from the beginning. Tara was very upfront about her mathematical content beyond elementary school and pedagogy confidence. It is important to note that her pedagogical confidence was with regards to the “new” way of teaching mathematics. The idea of using questioning and listening as a way to access student thinking as a teaching method was new to Tara. She was honest about this and consistently indicated that she was not comfortable with this method. However, at the end, her tune had changed. In October, Tara shared with the group that she was still uncomfortable allotting time, “the whole afternoon” (October audio reflection session) for students to experience tasks aimed at improving conceptual understanding. However, she shared that she was making an effort to improve her mathematical pedagogy. At the end of day 5 of the implementation, she wrote:
I extended Math for as long as I felt necessary to teach the lesson and for
the (students) to complete the activities. It was all hands on and the
students had to work together in groups and talk and discuss with each
other to complete activities. Normally I introduce the concept, we do
practice on the board and then the students do their worksheet
individually. This unit on measuring was all hands on and required me to
be more organized and prepared. (Day 5 final reflections)

When day 5 was done she was more confident with her execution of the lessons
but she still claimed some uneasiness.

I felt confident with the math content, and about how I thought the class
would flow and in my preparation this time, so I think the lesson went
pretty well. I am still struggling with checking my students thinking, so
sometimes I would forget to ask them questions while they were working.

(Day 5 reflections)

However, it is evident from her final reflection that she is confident with
reconciling the use of time with the necessity for understanding.

Mindy’s confidence levels were not always shared. Her sentiments were
expressed more circumspectively like when she asked to implement her lessons
later than Roxy. I suspected that it was a confidence issue with teaching my
lessons since they drastically differed from the way she presented her lesson.
However, she cited her school as the reason she couldn’t do it sooner. Although
this was probably also the case, later, she revealed “I was quite intimidated with
the lesson prior to collaboration sessions” (Day 5 final reflections). She continued
to say that through the availability of Roxy’s recordings and the collaboration
sessions, her confidence level grew:
I believe that having (Roxy’s) recordings helped me a great deal, as it was a great visual/model… (A)s we met more and I was able to gain immediate feedback, I began to remain confident in the lesson… Having (the researcher) point out some flaws that students made, made it easier for me to address the following day. (Day 5 final reflections)

Through continued opportunities to practice a problem-solving approach to mathematics and given a chance to collaborate with her colleagues, Mindy’s apparent growth in confidence to implement lessons in a manner similar to the lessons I wrote will also continue.

Confidence played a role in the success of the implementation. However, because the teachers had a willingness to experiment with the problem-solving approach and persevere, if they had any confidence issues, these teachers rose above it and continued to do their best. Confidence issues affected the way they thought about their teaching. It caused them to be more reflective and helped them understand where they felt they needed more work. With Heidi, the silly mistakes she makes in a lesson are addressed the next day. Roxy’s cognizance of the use of the base-ten blocks language alerts her when her students misuse the language. Tara’s lack of confidence in her questioning techniques affects her in the classroom and during the collaboration sessions. She is more aware of when she forgot to ask a question and she listens to the kinds of questions Heidi asked in class during our after school collaboration sessions. Mindy’s intimidation with the lessons kept her alert throughout the implementation process. She watched Roxy’s videos prior to implementation, she asked questions for clarification during the after school collaboration sessions, and she used the information from the videos and the after school collaboration to implement her lessons.
The combination of confidence level and support provided by the other teacher in the collaboration process led to the success - as I perceived it and more importantly, as the teachers perceived it – of the implementation of the lessons. Heidi and Roxy had high levels of confidence in teaching the culturally-based lessons from the beginning of the project. The support or lack of support of colleagues was not critical for two these teachers. Tara had a lower level of confidence so support from a colleague, Heidi, who had a higher level of confidence, was important in helping Tara successfully implement the lessons. Mindy also began with a lower level of confidence but lacked the same kind of support that Tara received from Heidi. Roxy, although at the same grade level as Mindy, was not from the same school and they had not implemented their lessons concurrently. Consequently, Mindy was not as successful as Tara in her implementation of the lesson and wanted to try the entire unit again the following week. Mindy did not experience the shift in her way of thinking about mathematics and teaching that Tara identified in this excerpt from her final reflection:

The biggest impact on my teaching would be the shift from just having the students do the work individually to having them work in teams and teaching them to work together, and communicate with each other to come up with their answer. Also getting ideas on how to manage the class with this kind of teaching and asking questions to get to each individual student’s level of understanding and thinking.

As a result of the experience, Mindy shared:

The biggest impact on my teaching from collaboration sessions was being able to quickly adjust and cater to the different students that needed it.
Having immediate feedback and suggestions (from the researcher) on how to address some issues helped me a lot and I know it benefited the students as well. (Final reflections)

Mindy benefited from the support I offered her. I believe that if she had the same support that Tara had, she may have had more success with the implementation of the lessons.
CHAPTER 5. DISCUSSION AND CONCLUSIONS

The goal of this study was to understand what happens when teachers collaborate to implement a mathematics unit designed to be culturally relevant and problem-solving rich. I believed that the teachers involved in the project would be positively affected and that they would gain some degree of acceptance of the new unit and the unit would be successfully implemented. As I collaborated with Roxy during the first implementation of the Size Matters unit in December, I suspected that the teachers would also grow professionally in the area of mathematics pedagogy. On the third day of implementation, during our collaboration session, Roxy commented that this was the first time she used base ten blocks to teach about decimals. She reflected that she typically uses money to teach decimals. She felt that the students were making better connections within the mathematics because they were able to link to their prior knowledge of fractions and think of decimals as also parts of a whole. She shared that she felt that I should offer professional development showing teachers various ways to teach mathematics using manipulatives.

Through our sessions together, I found our conversations not only revolved around the mathematics but also on the teaching of the mathematics. My findings revealed the kinds of impact (improved questioning techniques used by teachers, better understanding of the use of manipulatives in a lesson, enduring understandings gained by students, cultural connections, and confidence building) collaboration had on implementing something new that was not initiated by the teachers themselves. Three of the four participating teachers judged that the implementation of the unit was successful. However,
my findings showed that to varying degrees all four teachers in this study grew professionally through the use of the culturally-relevant, problem solving lessons and with the opportunity to collaborate with one another and with me.

My research points to the process I had the teachers experience through my project—teachers from the same school collaborated before the implementation of the unit to understand how the unit should be implemented, then during the implementation of the unit, they collaborated daily after each implementation session in class to discuss their successes and challenges, and finally, at the end of the implementation of the unit, the teachers reflected on the effectiveness of the lessons as a unit and discussed points for improvement for future use—as a possible tool for effective professional development.

Revisiting the Case Studies

Hiebert (1999) suggested that teachers need an opportunity to learn “new” ways of teaching. Although I would say Tara’s case was the most successful on its own, I cannot discount that the primary reason for her success is due to the fact that she had Heidi, a colleague at her school who was also part of the project and collaborated with her to help her learn the “new” way of teaching. Because of this partnership, I would say that this team experienced the most growth in mathematics teaching. Roxy also experienced success despite the fact that she did not have a colleague at her school who was also part of the project or wanted to put time into collaborating about the lessons in the unit. She, like Heidi, was a strong teacher in terms of her content knowledge and mathematics pedagogy. She and Heidi already believed in many of the Common Core Mathematical Practices and to some degree, practiced them in their classes prior to their involvement in the study. Roxy and Heidi both reflected on the positive impact
of a better understanding of the Mathematical Practices on their teaching and consequently, their students’ learning.

Mindy’s case illustrates a situation when the conditions for learning a “new” way of teaching are not optimal. Her case indicates that collaboration is not successful if the teacher starts with a low confidence level and does not have the support from her colleagues at her school. Future study could explore Mindy’s situation in more depth by asking, “Does any collaboration help or must the collaboration have teachers of different levels of confidence to be effective?” In Mindy’s situation, intervention by the state math coordinator or a state or district math coach could be helpful. The intervention should go through the principal of the school to instill a school-wide framework for the teachers to regularly collaborate about their teaching.

The process that was effective in this study requires a culturally relevant and problem-solving rich lesson plan, focused collaboration sessions with teachers from the same school, observation of implementation, feedback on observation through additional collaboration sessions the same day as the implementation, and daily written self-reflections. Although Roxy experienced success, her case cannot be used as a model for future researchers or practitioners because she already started off strong and her support needs were different from those of Tara and Mindy. Like Heidi, Roxy could probably grow professionally through self-study and without the collaboration but she felt that she was able to grow more through the experience with me. The focus of the after school collaboration sessions was on the success of students gaining understanding of the mathematics content through the framework of some of the Common Core process standards. Because my project was on a small scale, more research is
needed in this area to see if the outcomes are the same in other settings and with other teachers.

This process brought about change. It changed ways in which the teachers viewed the lessons and it changed the lessons themselves. The teachers used the collaboration as a tool to clarify parts of the lesson that were unclear or that required interpretation. Lesson plans require interpretation, especially if they were written by someone else (a partner in a school setting or a third party like a textbook company). Collaboration brings the lesson to life and allows it to take the shape necessary for the specific class and teacher utilizing it.

The educational community should study this process and consider it for professional development of its teachers. It could ask math peer coaches or mentors to play the role of the researcher. This approach may help schools deal with new curriculum mandates such as current efforts to implement the Common Core.

The Role of Culture

My research indicates that opportunities for cultural pit stops must be infused into the lessons. This provides further support for Wolcott’s (1982) notion that culture must be taught and suggests that it must also be explicit in the lesson. The problem-solving approach to mathematics lends itself to the Chamorro culture because the nature of the culture is community oriented. By infusing aspects of the culture into the lessons and framing the lessons in a community setting, the subtle relationship between the culture and the mathematics can be strengthened.

My research also indicates the relationship between culture and mathematics is subtle. In the grade 1 case, culture framed the context of the
lessons but the culture was never referred to again after the first day when the story was read. Note that only the Chamorro teacher who strongly identified with the Chamorro culture, Heidi, felt compelled to highlight the cultural components of the story. Tara, who had lived on the island for many years and called it her home, felt no such compulsion because she assumed that since her students were from the place, no elaboration was necessary. This implies that if more blatant cultural pit stops were desired then the lesson must be written explicitly to address the assumptions that might be made as they were in Tara’s case. I had assumed that as teachers in an indigenous context (the Pacific island of Saipan), the four teachers would understand and live the ideals of respect, reciprocity, and responsibility. While I was not mistaken, this assumption did not translate into the details of the lesson. For future research projects that include culture embedded in the lessons, the plans must be explicit as to where the cultural pit stops could occur.

In the grade 4 case, again, the relationship was subtle but had more of a presence because the lessons not only incorporated a story like the grade 1 case but it also linked to a present cultural concern: overfishing and an existing campaign to prevent overfishing. The students in these classes were working towards understanding the mathematical component of the campaign – the lengths of the fish to the nearest tenth of an inch. Although both teachers expressed discomfort in the Chamorro language in the story, the campaign ensured a tie to the culture throughout the lessons.

As Kaomea (2012) suggested, creating more of a presence in the subtlety of the lessons requires a link to not only the past, as the first grade lessons did through the story, but also to the present and the future as was evident in the 4th
grade lessons. In Heidi’s case, she linked the story to the present through her elaboration thereby creating more of cultural presence in her class than in Tara’s.

**My Participation and What I Learned**

My research question is important to me. I am a Chamorro from the CNMI who values my culture and mathematics framed within the Common Core Mathematical Practices. Because of who I am, I chose to be a part of the project and participated with the 4 teachers to the extent they allowed me. In all 4 cases, I observed the teachers directly or through their digital recordings, I read their daily reflections, and I observed and sometimes contributed to their daily collaboration sessions during the implementation phase of the lessons. My presence helped me better understand each teacher’s place in mathematics and culture. In the beginning, I was perceived as an authority of the lessons because I was the original writer of the lessons. I was careful to show them, through my words and actions, that my role was not that of an authority figure but to be an additional colleague in the process. As the number of days of implementation increased, their reliance on me as the authority figure waned and they saw me as more of a consultant. I learned that as a researcher and a participant, it was vital that I was clear of my role and the roles of the participants so as to minimize any intrusions on my part. The teachers in my study all reflected that they learned different things from their participation in the study. As a participant in the study, I too grew from the project. I grew as a teacher, as a researcher, and as a mentor.

The team of Tara and Heidi taught me the power of collegial collaboration. I understand better that for me to improve as a teacher, I need to team up with my colleagues at my school to reflect and collaborate on our
lessons. All the teachers taught me how to become a better researcher through their questions, their insights, and their challenges. I understood the importance of triangulation when one of my methods for triangulating my data failed as a result of technical difficulties. It was vital that I had other methods of data collection to aide in the analysis of my study. Finally, as a mentor for a couple of teachers at my school, my participation in this project has shown me that one of the components of an effective mentor, is one who is willing to go into the mentees classroom (or allow the mentee to observe me in my class) and use their exact experiences as springboards for discussion.

Final Thoughts

Part of the goal of this research was to increase knowledge regarding the exploration of teacher perceptions, attitudes, and work ethic to help future researchers as they work towards understanding the place of problem-solving rich ethnomathematics in the CNMI. My study has fulfilled this objective. From my study, future researchers can see that four teachers in the CNMI value collaboration and are willing to work towards having their students gain enduring understandings in mathematics through a problem-solving approach. These teachers also value mathematics lessons that link to culture. My analysis indicates that because a desire to fuse culture and mathematics exists with these four teachers of varied backgrounds, curriculum developers may want to continue the research with more teachers asking questions about culture and education to see if it is viable to create materials that link culture and mathematics and possibly other subjects. These curriculum developers may want to begin their studies by understanding the role of the Chamorro and Carolinian Language Heritage Studies program in the system. Additionally, since the
Chamorro culture was the focus of this study, future researchers could mimic the study with a focus on the Carolinian culture.

Because Saipan is a small island and I am in the same school system as the teachers in my study, it is inevitable that I encounter them in educational or community settings such as professional development meetings or at a store. I have run into three of the four teachers, Heidi, Roxy, and Tara since the project completion. Heidi is always eager to share how her students are performing or how they performed or any other aspect of her mathematics teaching with me. During our last encounter, she shared that all her students, except for one, scored on or above their grade level on a standardized test. She attributed her improved student scores to the collaboration sessions because the sessions caused her to be more reflective about her teaching making her more mindful of what she does in the classroom. She also shared that after I had left, she was given a student teacher from the local college. She required that teacher to watch her videos and teach mathematics in the manner shown in her videos. Should this collaboration process be required of pre-service teachers when they enter into their student teaching phase?

When I ran into Roxy at a professional development session, she shared that her students were so impressed with the story (Miura, 2011) from the unit that they had selected it to be one of the stories to be reread at the end of the year during her recap of the year. These kinds of follow up stories are evidence of the impact collaboration can have that extended the scope of this research and may be noteworthy to future researchers who may want to study what happens after teachers are exposed to intense professional development in the form of collaboration.
Appendix A

Teacher Debriefing Interview after Pilot Lesson

1. How effective was this unit in teaching mathematics concepts/skills that you teach at this grade level?

2. Were the activities fun and engaging for the students? Were they familiar with the activities?

3. Were the materials, handouts and other resources needed to teach the unit OK? Are these materials, handouts, etc. easy for you to obtain and make available for all your students?

4. How did the students respond when they saw that the lesson included activities from their daily life on their island?

5. Did the students’ response differ in any way from lessons that do not include examples from their own culture?

6. How did you know if the students mastered the mathematics concepts in the unit – could you rely on assessments built into the unit, or did you need to use your own ways to assess student learning?
7. What suggestions do you have to improve the unit – including the lesson organization, resources for the lessons and the assessments?

8. Would you want to teach this unit again in your class – if so or if not, please explain your reasons.

9. How has this unit in mathematics using cultural practices influenced the way you think about using our culture to teach school lessons? (How often do you use cultural practices to teach lessons in your classes?)

10. In your opinion, is it important to continue to develop lessons that draw on our own cultural practices to teach mathematics or other subjects? (What are your reasons for your answer?)

11. Do you have any final comments or questions regarding this interview or the pilot test?
Appendix B

Curriculum Unit – Pilot Test Review Form

**Lesson Unit Elements**

**Rating**

**Notes**

*Clarity of Purpose-Goals of Unit and Alignment with Local Standards and Ethnomathematics*

1. The purpose and goals for *mathematic learning* are clear and easy for the teacher to understand

   - o Good (Well described, clear for teacher and student)
   - o OK (Present in unit, but could be clearer for teacher or students)
   - o Needs Improvement (Needs to be rewritten for better clarity)

2. The purpose and goals for learning about the *local culture* are clear and easy to understand

   - o Good (Well described, clear for teacher and student)
   - o OK (Present in unit, but could be clearer for teacher or students)
   - o Needs Improvement (Needs to be rewritten for better clarity)

3. The learning objectives aligned with common core standards and/or with local MOE/DOE standards (*this is not a requirement of the unit, but we would like to know if there was alignment*)

   - o Good (There is alignment with common core or local standards)
   - o OK (With some additions/changes could better meet common core and/or local standards)
4. The unit promotes a coherent understanding of the use of mathematics within cultural practices.

- Good (The unit and lessons reinforce how mathematics is used in cultural practices)
- OK (The relationship of culture and mathematics could be strengthened)
- Needs Improvement (Unit mostly teaches Western math or a cultural practice with few connections made between them)

Teacher Preparation and Instructions

5. Instructions for the teacher on how to do the lessons are included in the unit and are clear and easy for teachers to understand.

- Good (Instruction clear, the teacher did not need additional explanations) The directions were clear but it helped to do it and learn some more and collaborating with the other first grade teacher helped more in the execution of the lesson: it provided a different perspective.
- OK (Needed some additional explanation)
- Needs Improvement (Need to improve instructions so teachers know how to do the lesson by looking at a lesson guide that explains how to teach the unit.)

Teaching or Instructional Strategies

6. The lessons encourage teachers to explore students prior knowledge and their understanding of cultural practices in their homes and community.
6. Teachers can easily draw out prior knowledge or home experience when discussing the lessons

7. The lessons are easily adaptable and flexible enough to meet the needs of students at varying levels of achievement

8. The lessons involved students in thought provoking activities in which they can ask questions and engage in conversations with each other and the instructors about their learning.

Pacing of the Lessons in the Unit

9. The skills and concepts evolve sequentially from lesson to lesson
10. Skills and concepts are sequenced in a way that allows mastery of learning objectives for both mathematics and cultural learning

- Good (Order of the lessons worked well)
- OK (Needed to make some minor revisions in the sequence) See #9
- Needs Improvement (Need to reorganize the way concepts and skills are presented to improve the flow of the activities and learning)

11. The lessons can be taught within the allotted timeframe

- Good (Lessons fit well into the time allotted)
- OK (Need to adjust instructions to explain the actual amount of time needed, but not by too much)
- Needs Improvement (Need to redesign the unit to include more or less lesson sessions to accomplish the learning objectives)

**Mathematics Vocabulary and/or Words in Local Language Are Included**

12. Mathematics vocabulary is grade-level appropriate and defined in student-friendly terms

- Good (Math vocabulary is taught or reinforced and is grade level appropriate)
13. Local language vocabulary related to the cultural practice is included and taught in student friendly ways

- Good (local language vocabulary is taught or reinforced and is grade level appropriate)
- OK (local language vocabulary is used, but not always grade level appropriate)
- Needs Improvement (Need to revise the use of vernacular vocabulary to fit within grade level)

Assessment of Learning

14. Student learning assessments are aligned with the content and learner activities

- Good (Assessments included in unit and are aligned with content and learner activities)
- OK (Assessment included, but not quite aligned to learning objectives)
- Needs Improvement (Need to include assessment)

15. Multiple methods are used to assess student learning

- Good (Both formative and summative assessment included)
- OK (only formative assesses or summative assessment included)
o Needs Improvement (Need to develop assessment resources)
Appendix C

Grade 1

Rationale: Measurement is a reality of life all over the world, the CNMI is no exception. We measure for cooking, weaving, cause building, making medicine, and so much more. First graders can make sense of the process of some measurement. First they can measure themselves then they can measure other objects. Understanding their heights in terms of objects they see on a daily basis can make learning the idea of measurement more meaningful.

**Desired Results**

**Skill Goals**
Measure height or length by iterating common objects.
Order objects by height or length using comparison.
Express order using comparative language.

**Common Core Mathematical Practices Goals**
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

**Essential Question**
What does a first grader have to think about and do when measuring height or length?

**Enduring Understandings**
To understand that measurement is a process of iterations.
To understand that measurement is a function of the unit used.

**Knowledge**
Objects have length.
Lengths can be represented with numbers.

**Common Core Standards addressed**

**LMD.1** Express the length of an object as a whole number of length units, by laying multiple copies of a shorter object (the length unit) end to end; understand that the length measurement of an object is the number of same-size length units that span it with no gaps or overlaps. Limit contexts where the object being measured is spanned by a whole number of length units with no gaps or overlaps.

**Assessment: Evidence**

**Summative/Formative Assessment Task**
Teacher observations.
Teacher eavesdroppings of student-student conversations.
Teacher-student conversations.
Daily reflections.

<table>
<thead>
<tr>
<th>Lesson Titles</th>
<th>Day 1: Jose's Many Heights</th>
<th>Day 2: Jose's Many Heights</th>
<th>Day 3: How tall am I? How tall are you?</th>
<th>Day 4: How long are the objects in my class? What does a pencil that is 4 paperclips long like?</th>
<th>Day 5: A Hunt for Objects of Various Unit Lengths or an Assigned Unit Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Half of the story</td>
<td>2nd Half of the story</td>
<td>Suggested Time: 60-80 minutes</td>
<td>Suggested Time: 40 minutes</td>
<td>Suggested Time: 40 minutes</td>
<td>Suggested Time: 40 minutes</td>
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<tr>
<td>Suggested Time: 15-20 minutes</td>
<td>Suggested Time: 15-30 minutes</td>
<td></td>
<td></td>
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170
Appendix D

Grade 4

Rationale: Measurement is a reality of life all over the world, the CNMI is no exception. We measure for cooking, weaving, canoe building, making medicine, and so much more. Fourth graders can make further sense of some measurement through the Size Matters Campaign. Understanding the importance of our oceans in our culture can make measurement more meaningful and purposeful.

<table>
<thead>
<tr>
<th>Desired Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skill Goals</strong></td>
</tr>
<tr>
<td>Express a fraction with a denominator of 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100. For example, express 3/10 as 30/100, and add 3/10 + 4/100 = 34/100.</td>
</tr>
<tr>
<td>Compare two decimals to hundredths by reasoning about their size. Recognize that comparisons are valid only when the two decimals refer to the same whole. Record the results of comparison with the symbols &gt;, =, or &lt;, and justify the conclusions, e.g., by using a visual model.</td>
</tr>
</tbody>
</table>

| **Common Core Mathematical Practices Goals** |
| 1. Make sense of problems and persevere in solving them. |
| 2. Reason abstractly and quantitatively. |
| 3. Construct viable arguments and critique the reasoning of others. |
| 4. Model with mathematics. |
| 5. Use appropriate tools strategically. |
| 6. Attend to precision. |
| 7. Look for and make use of structure. |
| 8. Look for and express regularity in repeated reasoning. |

| **Essential Question** |
| How does a 4th grade student decide when size matters? Why and when does size matter? |

| **Enduring Understandings** |
| To understand that size matters relative to the context. |

<table>
<thead>
<tr>
<th>Knowledge</th>
<th>Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length has a place outside of mathematics. Attention to precision and accuracy in length has value outside of mathematics. Values from different wholes cannot be compared.</td>
<td>Measure to the nearest tenths. Compare numbers in the tenths and hundredths place.</td>
</tr>
</tbody>
</table>

| Common Core Standards addressed |
| 4.NF.5 | Express a fraction with a denominator of 10 as an equivalent fraction with denominator 100, and use this technique to add two fractions with respective denominators 10 and 100. For example, express 3/10 as 30/100, and add 3/10 + 4/100 = 34/100. |

<table>
<thead>
<tr>
<th>Assessment Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Summative/Formative Assessment Task</strong></td>
</tr>
<tr>
<td>Teacher observations.</td>
</tr>
<tr>
<td>Eavesdroppings of student-student conversations.</td>
</tr>
<tr>
<td>Teacher-student conversations.</td>
</tr>
<tr>
<td>Daily reflections</td>
</tr>
</tbody>
</table>

| **Day 1:** Review of different units of measurements through drawing a fish |
| **Day 2:** Is my fish okay to eat? Uncle Greg’s Story: Size Matters Campaign |
| **Day 3:** Exploring tenths and hundredths: What does a 10.6 inch fish look like? *Suggestion: separate the students who are struggling with the concept and allow students who understand place-value to the tenths place to start on the research from day 6-8 |
| **Day 4:** Continuing the exploration of tenths and hundredths: Drawing line segments of various fish lengths with accuracy and precision. |
| **Day 5:** Continuing the exploration of tenths and hundredths: Paying attention to length accuracy but asking, “Does my fish look right?” |
| **Day 6-8:** What happens when size doesn’t matter; a closer look at the effects of overfishing |

171
Appendix E

Ethnic Composition of Classes Observed, SY 2012-2013

<table>
<thead>
<tr>
<th></th>
<th>First Grade Teachers</th>
<th>Fourth Grade Teachers</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>H</td>
<td>T</td>
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<tr>
<td>Chamorro</td>
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<tr>
<td>Thai</td>
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<td>0</td>
</tr>
<tr>
<td>Chuukese *</td>
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<tr>
<td>Tongan</td>
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<td>0</td>
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<tr>
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</tr>
<tr>
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<td>0</td>
</tr>
<tr>
<td>Palauan</td>
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<tr>
<td>Indian</td>
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<td>0</td>
</tr>
<tr>
<td>FSM</td>
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<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>25</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

*Source: Teacher communications*

*Note: Chuukese students are part of FSM.*
REFERENCES


Miura, D. (2009). *Jose’s Many Heights*. Unpublished manuscript, Department of Curriculum Studies, University of Hawai’i at Mānoa, Honolulu, HI.

Miura, D. (2011). *Uncle Greg Loved to Fish*. Unpublished manuscript, Department of Curriculum Studies, University of Hawai’i at Mānoa, Honolulu, HI.


