A STUDY OF CULTURALLY-BASED MATHEMATICS LESSONS IN AMERICAN
SAMOA AND THEIR INFLUENCES ON SELF, TEACHERS AND EVOLVING
PERSPECTIVES OF ETHNOMATHEMATICS AS A FIELD

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Abstract

The purpose of this study was to describe what was learned from culturally-based mathematics lessons in American Samoa and its impacts on the researcher and his students, inservice teachers. Secondly it aimed to describe my developing views of ethnomathematics as a field. A narrative research design was used to describe and analyze personal reflections on lessons that spanned three summers. After participating in the culturally-based mathematics lesson experiences, inservice teachers and I learned of the need for cultural sensitivity when dealing with westernizing cultural mathematics, the power of doing mathematics in cultural practices, the importance of elders in teaching culturally-based lessons, and the uncovering of connections between culture and mathematics and culture and the Science Technology Engineering and Mathematics (STEM) movement in education. To further elaborate on my developing view of ethnomathematics as a field I learned the importance of understanding ethnomathematical ideas through authentic cultural experiences, the importance of nonstandard measurements in cultural practices, and the increasing need to use culturally-based lessons to recapture our past.
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Chapter 1

Introduction

My background.

This dissertation begins with my life as a Samoan growing up in a South Pacific island culture and learning early on about my love for mathematics. It then continues as I reflect on my 18 years as a mathematics teacher working with both elementary students as well as inservice teachers from American Samoa and the important lessons learned along the way.

I was born and raised on the small island of Tutuila, which is the largest of a group of seven islands that comprise American Samoa, an unincorporated territory of the United States located in the South Pacific Ocean. American Samoa is located northeast of the islands of Fiji and southwest of the islands of Hawai‘i. The United States ceded the islands of American Samoa during the early 1900s, and the territory is currently administered by the United States Department of Interior’s Office of Insular Affairs.

Growing up in American Samoa, I was introduced to both Samoan and western traditions and customs. My father, Pemerika Tauiliili, is Samoan and my mother, Sylvia Blomerley, is English. My father was born in Leloaloa, American Samoa and my mother was born in Manchester, England. They met in the early 1960’s while pursuing their undergraduate degrees at the University of Hawai‘i at Mānoa. After college, they married and moved from Hawai‘i to settle in American Samoa. There they raised me, and my three older sisters. My mother worked as a registered nurse at the local hospital, while my father worked as an administrator in the Department of Agriculture. I learned both the Samoan and English language at home, school, and in church. I could read and write in both languages from an early age.
Because of my father, we celebrated many Samoan traditions that were heavily influenced by the Methodist church such as White Sunday and New Year’s Eve worship services. I participated as a young boy in Samoan funerals, weddings, church dedications, and bestowment of chief titles, which were events that were heavily laden with the use of the Samoan language and traditional Samoan cultural practices.

Because of my mother, I learned to speak English very well and remembered having many conversations with her in English about life outside of American Samoa. I was also blessed to live next door to my mother’s father and mother, Dr. Leslie and Emily Blomerley, from whom I learned a lot about my English heritage and history. They were also great influences on my learning of the English language and culture. Both my parents and their immediate families influenced my learning of Samoan and English customs, languages, and traditions.

Getting a good education, attending church regularly, and learning the English and Samoan languages and cultures seemed very important things to my parents. As a result, all of my siblings were encouraged to attend college and they all obtained at least a master’s degree in their respective fields. We were also encouraged to be active members of my father’s Samoan speaking Methodist congregation, attending church every Sunday, singing in the church choir, and participating in the church youth group. I remember attending many church functions all of which were infused with Samoan cultural practices, languages and customs. In doing so we fulfilled one of my father’s wishes—that we understand and practice the Samoan culture and learn the language.

My father wanted all of his children to learn the cultural traditions that he practiced as a young boy. I remember that he loved to share his experiences growing up as a young Samoan in both Samoa, formerly known as Western Samoa, and American Samoa where we were born and
raised. He was constantly involved in traditional Samoan cultural practices because of both his status as a high chief and because this was how he chose to live. I owe most of my knowledge of the Samoan way of life to him and to my extended family on my father’s side.

My mother is a soft-spoken woman who loves to celebrate family traditions such as birthdays, Christmas, and especially Thanksgiving. I remember her spending time cooking pumpkin pies, turkey, and stuffing for Thanksgiving at a time when most Samoan families didn’t necessarily celebrate Thanksgiving with the same customary western foods. We were introduced to a lot of western customs and traditions by my mother and I am grateful that I have those memories. I still carry on many of those same traditions today with my own family.

**My life as a young Samoan male.**

As a Samoan male, I was expected to know how to perform certain cultural duties. Cultural duties of men and women were typically different. One of the duties I learned to perform was the preparing of traditional Samoan food in an *umu* (cooking of food using firewood heated stones usually performed by the males only). Every Sunday or on special occasions the adult and young males would spend time preparing and cooking an *umu* for an afternoon feast. In my family I was amongst a group of Samoan males that consisted of cousins, uncles, and my father. My training in Samoan cultural practices that pertain to males began very young and my memories of these events begin when I was about seven years old.

As the youngest male in the group it was my role to watch and observe and to fetch materials needed for the *umu*, what Bandura (1997) calls observational learning. Early on I was given menial tasks but worked my way up and was gradually given more responsibility. It was during these tasks that I learned how to prepare at least 10 different traditional foods, weave an *ato launiu* (a coconut frond basket), light the firewood, husk, peel, scrape, and squeeze the
coconut shreds to make coconut cream, and ultimately serve the food to adults in a formal Samoan traditional setting. It was at this time that I learned from my uncles, cousins, and father many of the responsibilities of a young Samoan male through my performance of Samoan cultural practices.

When I was about 14 years of age, I began to experience a transition in my role as younger male cousins began to participate in our cultural practices. I realized my role had shifted as I began to fulfill the role my older cousins and uncles had played in previous years. Because I was older than this new group of younger Samoan males I would require them to observe first, and then help with menial tasks. This felt like an important time for me to follow in my uncle’s footsteps and teach the younger cousins everything I knew. One important realization about teaching and modeling the cultural practices, which I realized early on, was that teaching took time. For example if I performed a task on my own without stopping to show my cousins how to do it the task was quickly completed. However when I slowed down and showed my younger male cousins how to perform a cultural task, it took longer. If I had them try to complete the cultural practice on their own it took even longer and I would run the risk of it being done incorrectly. I realized at that moment the importance of time constraints as a factor in teaching along with opportunities for experience. When there was time to teach, the elders gave opportunities for the younger males to gain some experience.

To help illustrate the roles of Samoan males within a cultural practice such as making an *umu* in relation to their age and experience I created the following: Table 1.1. Entries are based primarily on my own family group and only reflect those relationships between age, experience, and responsibility that I have personally witnessed.
Table 1.1

*Responsibilities of Samoan Males by Age and Experience.*

<table>
<thead>
<tr>
<th>Age of male</th>
<th>Level of experience and awareness</th>
<th>Duties or Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30+ years old</td>
<td>older males with a lot of experience in important cultural practices</td>
<td>asked to facilitate tasks and guide the work of all participants as well as perform all major tasks with little to no help</td>
</tr>
<tr>
<td>14 years and older</td>
<td>older males with some experience</td>
<td>asked to assist or perform all major tasks</td>
</tr>
<tr>
<td>14 years and older</td>
<td>older males with little to no experience</td>
<td>asked to observe and assist on menial and major tasks</td>
</tr>
<tr>
<td>8-14 years old</td>
<td>younger males with some experience</td>
<td>asked to observe and assist on menial to major tasks</td>
</tr>
<tr>
<td>8-14 years old</td>
<td>younger males with little to no experience</td>
<td>asked to observe and assist with menial tasks</td>
</tr>
</tbody>
</table>

**My education and love for mathematics.**

From 1979 to 1987, I attended both public and private schools. During my elementary years, I remember excelling in mathematics. I realized then that I was good at remembering facts and identifying patterns, which helped me in elementary mathematics tasks. In 1987, I began high school and attended a Catholic all-boys school known as Marist Brothers High School. It was early on in high school that I realized that mathematics would continue to be my passion and that I would pursue a career that involved mathematics. Part of this passion I owe to a very special teacher, my freshman and sophomore mathematics teacher, Joe Lunanova. He was my favorite high school teacher. He was the type of teacher who explained algebra concepts in ways that were easy to understand.
**Moving to Hawaiʻi in 1992.**

In 1990, I graduated from high school as the salutatorian, then attended the local community college for two years and earned an associate’s degree in liberal arts. After my time at the community college I moved to Hawaiʻi to continue my education at the University of Hawaiʻi at Mānoa and pursue a degree in accounting. I lived in an urban area close to the university and attended classes and worked part time. While in Hawaiʻi, I didn’t have Samoan friends or family who practiced a traditional Samoan way of life. I remembered missing the experiences of cooking and serving Samoan food in the traditional manner and opportunities to perform Samoan cultural practices. I remember worrying that I would forget the Samoan language. My father gave me a Samoan Bible when I left American Samoa so I could practice reading in Samoan while living in Hawaiʻi. When he came to visit me in Hawaiʻi he insisted that we both converse in Samoan as much as possible.

In the middle of my second year at the university, I discontinued college, got married, and started a family. I married the most amazing woman, Druscilla Roberts, and we had our first son, Darien, in 1994 and our second son, Taylor, two years later. I lived with my wife and two boys in Hawaiʻi for another three years and worked as a waiter, a construction worker, and a security guard. In 1997, at the age of 24, I returned to American Samoa to be closer to family and to seek support in raising our two children.

**Returning to American Samoa in 1997.**

When I returned home to American Samoa, I realized this would be my time to fulfill my father’s role and pass on cultural knowledge to my own children. Moving back to American
Samoa was an important move for me as a Samoan male because I was able learn more about the culture and language.

In the next 14 years we continued to live in American Samoa and grow as a family. My wife and I eventually had a total of six children, four boys and two girls. My father insisted that my children learn the Samoan language and become active in the Methodist church. This is important, as I had mentioned earlier because the Samoan Methodist church events were heavily influenced by Samoan cultural practices. My participation as a young boy in the Samoan Methodist church events taught me a lot about the Samoan language, culture, traditions, and cultural etiquette. My father and I hoped that it would do the same for my children.

While in American Samoa, my children attended public schools, and learned most of their Samoan language from their peers. Only recently have I realized that this was quite different from my Samoan culture and language learning. I felt that I learned the Samoan language most from my early interactions with my extended family and church peers. I also realized that my children were not exposed to the same type of Samoan cultural experiences that I was exposed to as a child. One reason for this was the fact that I was not as active in the Samoan Methodist church as an adult as I was when I was younger. This meant that my children did not get the opportunity to perform as many Samoan cultural practices as I did as a young active church member. Because of this they missed out on many cultural experiences and did not learn the Samoan language as well either. This realization of the impact the Samoan Methodist church had on my knowledge and skills of the Samoan culture and language was important to me.

While raising a family in American Samoa, I was fortunate to live close to my two older sisters Ruth Tauiliili-Mahuka and Gwen Tauiliili-Langkilde and their families. Like me, my two
sisters attended college in Hawai‘i, married, and then started a family. Soon after college they too moved to American Samoa. My two sisters had children who were around the same age as my children. As a father and an uncle I spent time with my children and nieces and nephews practicing Samoan cultural traditions. Many of these traditional cultural practices involved the making and serving of Samoan food for Sunday brunch. This was important as my brothers-in-law, my sisters’ husbands, and I tried to continue the role of older males passing on the knowledge and skills of Samoan cultural practices to our children.

**The importance of learning by doing.**

As a young Samoan I learned a lot of the cultural practices by watching and observing in hope that one day I might be in charge and practice these skills on my own. I watched my father and uncles perform cultural practices that I did not have the chance to perform by myself. Then I would assist but not fully complete cultural tasks alone. Now that I was older and had to teach these skills I realized something important. I was surprised at how many of the steps of the cultural practices I remembered. As I taught my nieces and nephews how to weave a basket or prepare Samoan food I began to recall steps of the process. What helped me recall them was that most of the steps had logical progressions, which I understood more as an adult, coupled with my own experiences of cooking food. I felt confident teaching my sons and nephews because I could recall and perform the tasks and teach them. I remembered thinking as I watched the boys try to awkwardly perform the tasks for the first time, “This must be what I looked like to my uncles as I was learning this for the first time.”

However there were times when I would forget a few steps in the process, forcing me to seek information about the cultural practices from my father. When I came across a cultural practice that my nephews or sons were performing, like weaving a coconut frond basket, and I
had to have my father teach me how to braid the bottom of the basket again, I realized that I
yearned to pass on the knowledge and the skills correctly and make sure I recalled things
correctly.

I noticed that many of the tasks I had actually performed frequently when I was younger
like husking and scraping a coconut I could recall and perform easily. However, when it came to
practices I had not actually performed by myself such as gutting a pig, but involved tasks that I
helped my uncle perform on numerous occasions, I could recall with some high percent of
accuracy but not completely. However, cultural tasks that I had only observed others do and did
not actually perform or assist in performing I realized, depending on difficulty, that I could not
duplicate them with much success. This made me realize the complexity of the relationship
between learning by doing and learning through observation. This relationship in learning will be
covered in more detail later in this paper. I also realized the importance of having a community
of elders around to help preserve and pass on cultural knowledge and skills, which will also be
discussed later. Finally reflecting on these experiences helped me realize how important it was
for me to be back in American Samoa to continue to learn the role of an elder in my own family.

**My teaching career begins.**

When I arrived in American Samoa I began looking for a job. One of the first jobs that
appealed to me was a teaching job offered at my alma mater Marist Brother’s High School. I was
hired in the fall of 1997, with no teaching experience, a few months after moving back to
American Samoa. I started my teaching career as a high school mathematics teacher teaching 9th
grade Algebra, 10th grade Geometry, 11th grade Algebra II, and 12th grade Accounting. Marist
Brothers High School was an all-boys Catholic high school with an enrollment of approximately
150 students. I was one of about 13 teachers on staff and one of the two mathematics teachers.
During my three years teaching at Marist Brothers High School, I realized that I loved to teach and felt a passion to work with children. I felt I had a lot to offer in terms of my post high school experience having attended both the local community college and the University of Hawai‘i pursuing my accounting degree. I also realized that I could become a good mentor giving experiential advice to the young boys about making both career and college bound decisions. And most importantly I realized that I loved to teach mathematics.

The mathematics curricula at the high school consisted of material from dated textbooks. Most of the material I used and my style of teaching was a traditional style of teaching. Battista (1999) offers an explanation of what I mean by “a traditional style of teaching”:

In traditional mathematics instruction the mathematics covered is almost identical to what most adults were taught when they were children. Students spend most of their time attempting to learn traditional computational procedures – that is, things that can be done by calculator. Furthermore, the focus on computation is so myopic that few students develop any understanding of why the computations work or when they should be applied (p.428).

Technology was limited to overhead projectors and we did not have any mathematics manipulatives or computer software. All assignments and tests were from the textbook. I had had no previous teacher training and I literally learned my job on the job.

During the three years of teaching at Marist Brothers High School I felt a desire to improve my teaching skills and receive training on how to be a better teacher. In the fall of 2000, three years after I began teaching, I heard of a program that would help me earn my bachelors of education degree whilst still teaching in American Samoa. Local teachers were able to take courses at night and earn a degree in education. So I decided to pursue this and apply to be a part
of the next teacher cohort with the University of Hawai‘i Cohort Program. The University of Hawai‘i Cohort Program is an outreach program of the University of Hawai‘i at Mānoa College of Education that offers bachelors of education degrees with an emphasis on elementary education to elementary inservice teachers in American Samoa. However, in order to enroll in the next teacher cohort I was told that I had to be teaching in an elementary school. So I resigned from Marist Brothers High School and applied for a teaching job with the American Samoa Department of Education (ASDOE) to teach in an elementary or middle school.

In the fall of 2000 I was hired as the 7th grade middle school mathematics teacher at Manulele Junior High School, a public school in the ASDOE. The mathematics curricula at the middle school included student workbooks, extension activities, manipulatives, and the school offered teacher workshops I could attend after school. However, I still felt that I needed to be a better teacher so I aggressively sought enrollment in the bachelors of education program. I applied to the University of Hawai‘i Cohort Program in the fall of 2000 and was accepted in the spring of 2001. I attended courses from the spring of 2001 and earned my bachelor’s degree in the fall of 2003.

The impact of the University of Hawai‘i Cohort Program on my teaching.

I eagerly attended my first course with the University of Hawai‘i Cohort Program. After three and half years of teaching mathematics, I was ready to learn new teaching strategies and educational philosophies from the instructors as well as other experienced teachers. There were three important impacts to my teaching gained from that two-year experience: (a) teaching confidence, (b) a sense of belonging to a society of teachers, and (c) improvement in my understanding of core concepts in mathematics.
I realized that my confidence as a teacher was substantially greater every single week. Most of this stemmed from my experiences discussing, reading, and observing educational work each week in my university courses. I found I learned the most about teaching by talking and listening to other teachers. We shared stories and highlights from our days in the classroom and these helped me grow in confidence. I could relate to many of these stories and they helped me realize that I was not the only one out there. In turn I gained a self-awareness of what it took to be an effective teacher and I learned to use others’ experiences to help me deal with issues in my own teaching. I also learned a lot from my direct observation of other teachers and the wealth of strategies and ideas that they shared during course lesson presentations. During every course teachers were asked to prepare lesson presentations and it was during these presentations that teachers demonstrated creative, motivating, and engaging teaching strategies. I would borrow these ideas and use them as my own. As I tried new strategies in my own classroom, my students gave me great feedback that in turn boosted my confidence.

The second impact of the University of Hawai‘i Cohort Program on my teaching was a sense of belonging. I got a chance to meet many teachers in the program and learned that being a part of a cultural group was an important part in realizing my identity as a teacher. Each time I think about my experiences observing and conversing with teachers in and out of classes, I felt a strong kinship and feeling of belonging to a dedicated core of individuals. This occurred more during these two years of night courses than from my own daily experiences with teachers that I taught with before entering the cohort program. This was perhaps because my interactions with cohort classmates were more profound and meaningful because there was time set aside for reflection about our practice, something that does not often happen during a typical school day. I was also able to reflect intently and concentrate on the nuances of teaching within a cultural
family group. I felt that being a part of this group helped me to grow as an individual as well as share and contribute to the group with any experiences or ideas I had about teaching.

Thirdly I feel that my experience as a mathematics teacher grew substantially through the university courses that I took. Each undergraduate teacher was required to take two mathematics methods courses. These helped me develop a greater understanding of the core concepts of mathematics. We had an excellent mathematics instructor, Ms. Sofai Tuatoo, who helped us understand the importance of using concrete and pictorial examples to help build important mathematics concepts for children. In turn, using these examples in class helped me gain a deeper and richer awareness of mathematics and strategies to teach mathematics better. I owe a lot to her for her ability to help simplify and breakdown mathematics in a logical and easy to understand way.

**My teaching career continued at the college level.**

In the spring of 2004, shortly after earning my bachelors of education degree, I left the middle school to accept a position as a field supervisor for University of Hawai‘i Cohort Program. As a field supervisor, I was responsible for conducting field observations of inservice teachers who were working towards earning their bachelor’s degree. I traveled to schools across the island visiting inservice teachers and conducting evaluations of their teaching.

That same spring, I began a master’s degree program with the Curriculum Studies department of the University of Hawai‘i, with an emphasis on mathematics education. My fellow master’s degree candidates and I were fortunate to have great mathematics instructors, Dr. Neil Pateman and Dr. Sandy Dawson from the University of Hawai‘i, who offered courses in person or online. The courses focused on helping teachers understand the current trends in mathematics education, improving teachers’ problem solving skills, and developing an understanding of
mathematics within a conceptual framework. The master’s degree program helped me develop my understanding of the field of mathematics as well as have a huge impact on my teaching and research in education. At the end of the master’s degree program I wrote a culminating paper using action research as a methodology to help me analyze my own teaching practice.

This self-study focused on my questioning practices during mathematics lessons. I focused on analyzing the types of questions I asked, how often I asked each type of question and their effects on student interaction. Although I thought I was good at asking deep, thoughtful questions to get students to reach a deeper levels of conceptual understanding, I realized that I spent too much time leading conversations with a few students in whole group discussion instead of allowing students to have their own meaningful conversations. This taught me that I needed to help students become an integral part of the dialogue in mathematics lessons. From that point on I tried to minimize the time I spent using direct instruction in order to increase the opportunities for student dialogue.

After I earned my master’s degree in curriculum studies with an emphasis in mathematics education from the University of Hawai‘i in 2006, I was promoted to cohort coordinator with the responsibility of supervising a cohort of inservice teachers. I also taught the two mathematics methods courses.

The material I prepared to use to teach mathematics to inservice teachers, was mostly drawn from my own experiences as a student in the program coupled with my own research on effective methods of teaching elementary mathematics. I also learned from my discussions with faculty who had been teaching mathematics and used the resources they provided for me. I also used several resources and teaching strategies I learned from my professors during my master’s degree program.
My first year teaching mathematics methods courses to in-service teachers was marked as another step in my learning process of how to become a good mathematics teacher. I continued to work on my questioning skills while helping teachers analyze the mathematics standards that they were required to teach. I introduced the teachers to ways to teach students using both mathematics manipulatives as well as pictorial representations, and to assess students’ conceptual understanding of mathematics through (Stanic & Kilpatrick, 1989). As I reflect back on my teaching I realized that I was continuing my journey of shifting my skills and knowledge of mathematics teaching away from lecturing, and directing them towards guiding, asking, and inviting.

In 2010 I decided to pursue my doctoral studies. I applied and was accepted to join a group of Pacific island teachers in a program called Project MACIMISE. I will be explaining what Project MACIMISE stands for in detail in the next chapter. In 2011, a short while after I started my doctoral studies in the field of mathematics education, I moved from American Samoa to Utah with my family. I continued my doctoral studies while in Utah.

**Where am I now?**

In 2011, I was hired as a teacher’s aide in the Washington County School District (WCSD) and spent about five months helping out elementary students in small groups. In the spring of 2012, I was hired in the same school district to fill a teaching vacancy to teach 6th grade mathematics at an intermediate school. In the fall of 2012, I was hired to teach Science Technology Engineering and Mathematics (STEM) at an elementary school in the WCSD. In the fall of 2015, I am currently in that same capacity as a STEM teacher at the same elementary school.
Chapter 2

Project MACIMISE

What is Project MACIMISE?

Project MACIMISE (Mathematics and Culture in Micronesia: Integrating Societal Experiences; pronounced as if it was spelt “maximize”) is a National Science Foundation (NSF)-funded project that focuses on the languages and cultural practices of the peoples of American-affiliated islands of the Pacific region that encompass at least 10 distinct language groupings. The islands of the Pacific are spread across 1.5 million square miles yet have a total landmass of less than 1,000 square miles. (Dawson, 2013, p. 44)

Furthermore:

The first goal of this Project is the development of elementary school mathematics curricula sensitive to indigenous mathematical thought and experience. A necessary prerequisite for the achievement of this goal is to recapture and honor the mathematics developed and practiced in the Micronesian communities. This is the Project’s second goal. The third goal of the project is to build local capacity by offering advanced degree opportunities to the indigenous mathematics educators who transform what they find in their local cultural practices into grades one, four, and seven mathematics curriculum units. (Dawson, 2013, p. 43)

During Project MACIMISE the Pacific island participants, including myself, took online courses dealing with both learning and teaching mathematics as well as aspects of educational research. The participants in Project MACIMISE were all educators who held capacities in varying areas of education, including teaching in elementary, middle school, high school or college contexts. One night a week all the MACIMISERS, as we were called, met online with
one or two instructors during the spring and fall semesters of 2010-2013, and met face-to-face for at least one week during the summers of those same years. We held two extra face-to-face meetings in the summers of 2014 and 2015.

My own personal journey with Project MACIMISE began in the fall of 2009 at an opening ceremony for University of Hawai‘i faculty at Mānoa campus, when I was invited by the late Dr. Sandy Dawson to apply to be part of the project. The idea of joining a federally funded project to earn my doctoral degree was very appealing at the time so I applied and was accepted into the program.

Project MACIMISE consisted of 21 Pacific island educators, 11 of whom were working towards their master’s degree in curriculum studies with an emphasis in mathematics education. The other 10 were working towards their doctorate of philosophy in education with an emphasis in curriculum and instruction. Thus each Pacific island participant was given the opportunity to earn either a masters or doctorate degree with the university affiliated with Project MACIMISE, the University of Hawai‘i at Mānoa. Project participants were from the entities of Yap, Kosrae, Chuuk, Palau, Pohnpei, Guam, Saipan, Commonwealth of Northern Marshall Islands, American Samoa and the state of Hawai‘i. MACIMISERS took a few online courses together as an entire cohort. Other doctoral level or masters level courses were taught separately to the appropriate sub-group.

Project MACIMISE staff consisted of two principal investigators, Dr. Sandy Dawson and Dr. Tom Craven, and an advisory board consisting of educators from universities across the Pacific, North and South America, many of whom were prominent in the field of ethnomathematics. In addition, instructors from the University of Hawai‘i at Mānoa who helped teach research courses. Before the first MACIMISERS meeting took place, I was informed that
the main focus would be ethnomathematics research. Detailed information about ethnomathematics as a field and as a topic of research will be discussed in the second half of this chapter.

**Project MACIMISE summer meetings.**

From 2010-2015 Project MACIMISE participants, principal investigators, guest instructors, and advisors met each summer on one of the island participants’ home islands. The summer meetings took place in Saipan in 2010, Pohnpei in 2011, Palau in 2012, Saipan in 2013, Hawai‘i in 2014, and finally on the Marshall Islands in 2015. These summer meetings allowed Project MACIMISE participants and advisors to: (a) follow up on master’s plan b or dissertation research, (b) continue with university coursework, (c) share cultural practice presentations from each participant’s home island, (d) explore the rich culture of each island, (e) attend and present at educational conferences, as well as (f) work on designing and evaluating culturally-based mathematics unit plans for grades one, four, and seven.

An important activity during the summer trips was the opportunity to form a circle and share ideas and thoughts openly with each other. The “circle,” as it was officially coined by the late Dr. Sandy Dawson, was a time for members of the MACIMISE family of participants and university advisors, to speak and reflect on their rich experiences with culturally-based mathematics education. The circle time would begin with Dr. Sandy Dawson taking a talking stick and reminding people of the etiquette of circle time. The main point of etiquette was that once someone had the talking stick he or she was given the full attention of the group and was allowed to share and reflect on personal experiences, ask questions, or answer questions posed by others. Circle time became a powerful tool to help us synthesize information, share laughter
and tears, understand each other, and to foster mutual respect for each island culture and each of the members of the MACIMISE family.

First face-to-face visit in Saipan and what was learned there.

In the summer of 2010, after our course with Dr. Don Rubenstein, the journey with MACIMISE continued with a trip to the island of Saipan. It was during this trip that we all met face-to-face for the first time. We continued on with coursework prescribed for those participants working toward their masters or doctoral degrees. It was then that we got to see more examples of ethnomathematics during our cultural presentations. Each participant from the entities of the Federated States of Micronesia (Yap, Chuuk, Kosrae, and Pohnpei), the Republic of Palau, Guam, the Commonwealth of the Northern Marianas Islands, the Republic of the Marshall Islands, the Territory of American Samoa and the State of Hawai‘i were given an opportunity to share a cultural experience with the group. This was a very special time for me to grow in my testimony as a mathematics and Pacific island teacher. My awareness of ethnomathematics as a global, yet integral, aspect of Pacific peoples’ way of life began to unfold.

![Figure 2.1: MACIMISE family in Saipan 2010.](image-url)
Learning and presenting at education conferences.

Summers were also spent attending Pacific Educational Conferences (PEC) in Pohnpei in 2011, Saipan in 2013, and the Republic of the Marshall Islands in 2015. These educational conferences were focused on educational issues particular to island communities and were attended by Pacific Island teachers from as far northeast as Hawai‘i, as far west as the Republic of Palau, and as far south as American Samoa. These education conferences were opportunities for most MACIMISERS to present their ethnomathematics research as well as on personal topics of interest.

In addition to summer meetings MACIMISERS had opportunities to attend mathematics conferences during the academic year. Each spring the National Council of Teachers of Mathematics (NCTM) holds an annual conference. MACIMISERS attended those held in Indianapolis in 2011, in Philadelphia in 2012, and in New Orleans in 2014. At each of these three conferences MACIMISERS attended presentations that varied from topics that were of personal interest to those that were focused on ethnomathematics. Also during the Philadelphia conference, three MACIMISERS co-presented on mathematics strategies teachers could use in the classroom. In 2013, a few MACIMISERS attended international mathematics conferences in Canada and Korea where they participated in panel discussions on the potential role that Project MACIMISE had in advancing the field of ethnomathematics.

Ethnomathematics as a Field.

What is ethnomathematics?

Ethnomathematics describes a field of mathematics that is focused on the connections among one's cultural practices and the mathematical knowledge and methods used to accomplish
that practice (D’Ambrosio, 1997). It deals with mathematics that a society and its people have developed or use to solve daily problems that they face. Ethnomathematics is also a term that encourages ethnic groups from many societies to realize that mathematics is everywhere and that it is practiced in different ways all around the world. Rauff (1998) thought that ethnomathematics allows examination of the way mathematical ideas are manifested in various cultures, and how that can “lead us to some cross-cultural harmony” (p. 9). Ethnomathematics is a study of mathematics that is quite different from academic mathematics because it deals with real contexts, real problems, and real people (D’Ambrosio 1997). And as Sleeter (1997) pointed out, mathematics and cultural context are hard to separate.

Barton (1996) asserted that ethnomathematicians, such as D’Ambrosio, Ascher, and Gerdes, each suggest that ethnomathematics poses political problems and leads to societal impacts because it rejects the notion that all mathematical theories are essentially derived from a small number of European societies. Ethnomathematicians refute the notion that those theories form the only mathematics worth knowing. “‘Ethno’ shifts mathematics from the place where it has always been glorified (university and school) and spreads it to the world of people, in their diverse culture and everyday actions” (Pais, 2011, p. 210). In my personal experience, students in schools are not taught to realize that mathematics is a process that is derived from the daily activities of people. In fact young students and their families practice mathematics on a daily basis often times not being aware of it. Students will often say to me that mathematics is only practiced in school, learned by solving problems in textbooks, taken on tests, and taught by school teachers. Ethnomathematics challenges the notion that mathematics can only be taught in a formal setting. It allows people to explore the type of mathematical thinking and processes that take place with everyday activities (Rosa & Orey, 2011).
Ethnomathematics is a field that studies the awareness people gain from this type of mathematical thinking, discovers how it aids in the survival of a people, communicates mathematical thinking to a younger generation, and most importantly celebrates the fact that mathematics is embedded in people’s own actions and thoughts. Bishop (2002) describes ethnomathematics as a theoretical concept that addresses the idea that “mathematical knowledge is a cultural product and that mathematics education is culturally shaped” (p. 120).

Ethnomathematics is also a celebration of one's cultural and local knowledge and skills because it gives credit to those who practice a cultural activity and in doing so learn to estimate, measure, and discover patterns. It validates cultural knowledge held by elders in what D’Ambrosio called a “restoration of cultural dignity” in his foreword written for the book by Greer, Mukhopadhyay, Powell, and Nelson-Barber (2009).

Cultural knowledge comes with practice and experience and in time sensible estimates of numbers (e.g., how many taro (tuber root) do I need to grow to feed a family of ten?), measurements of time (e.g., how long does it take to weave a basket, build a Samoan fale (house), weave a mat, cook taro?), and discovery of patterns (e.g., how many overlaps are there in a coconut frond basket before it is braided at the bottom?) all become second nature. As I reflect on my own experiences, the acquisition of my cultural knowledge, and the knowledge of those elders from whom I have learned, I realize that these mathematical ways of thinking (estimating, measuring, and seeking patterns) are a vital part of completing daily tasks with ease. For example, the pattern recognition required to develop the skills of weaving a Samoan basket takes a lot of practice to master. One needs to identify the various patterns, memorize those patterns, and finally, continue or reverse a pattern when corrections are needed.
Ethnomathematics is a way of thinking mathematically, taking into consideration time and place, people and their environment, ways of thinking and especially the performance of everyday tasks, even those not considered mathematics. In his summation of different viewpoints of experts in the field of ethnomathematics, Barton (1996) states his definition of ethnomathematics as, “… a research programme of the way in which cultural groups understand, articulate and use the concepts and practices which we describe as mathematical, whether or not the cultural group has a concept of mathematics” (p. 214).

Although ethnomathematics has steadily grown as a legitimate perspective in mathematics education research, there still needs to be more research on the connections among it and mathematics, and especially of how educators use ideas of ethnomathematics in the classroom. Pais (2011) brought up important questions about how mathematics educators link cultural practices done in a real world context with classrooms that are often sterile of this authentic dimension. He warned of the dangers in transferring indigenous knowledge in western terms, and devaluing the true meaning of the cultural practices through inappropriate forms of teacher translation.

Finally my involvement in ethnomathematics as a mathematics educator helps establish my definition of ethnomathematics, influenced by both research in the field as well as my involvement with Project MACIMISE.

My definition of ethnomathematics is as follows; a field of mathematics which honors and respects the cultural knowledge and skill of elders passed on from generation to generation through cultural practices and derives from it conceptual knowledge and practical skills that are categorized as mathematical.
My first experience with culturally-based mathematics as applicable to American Samoa.

In the spring of 2010 our MACIMISE journey began with our first online course. We received an introduction to both the Pacific island teacher participants as well as our Project MACIMISE principal investigators. The first course was taught by Dr. Don Rubenstein a cultural anthropologist from the University of Guam. The course served as an introduction to educational research and a springboard to learn about culturally-based mathematics. This, in turn, helped introduce us to an aspect of the field of ethnomathematics.

During an inspirational journey of learning you have pivotal moments that provide clarity and a new understanding or awareness. The first course we took with Dr. Rubenstein provided an important opportunity to research and discover what culturally-based mathematics and the field of ethnomathematics meant to us and our own island people. Our main research assignment for the course required us to get in touch with our local elders and choose an aspect of our culture that we felt had mathematics embedded in its practice. We were asked to present to the class mathematical ideas or concepts we discovered or uncovered in our own local cultural practices.

I decided to do research on the cultural practice of Samoan siapo painting. First I will give an explanation of siapo, and then I will share how I learned about this practice.

Siapo is a Samoan word for bark cloth made from u’a or paper mulberry tree that has been painted or printed with various design motifs. Although Samoan siapo can be distinctly recognized as a pure art form that flourishes in Samoa, its origins can be traced to eastern Asia (Neich & Prendergast, 1997).

There are two distinct forms of siapo printing known in American Samoa. The first type and perhaps the more traditional is the siapo elei. Siapo elei are large sheets of bark cloth that are
imprinted using a template stamping process. This template stamping is done by placing portions of the cloth on a large design tablet made of wood called an upeti. This wooden tablet is about 1 foot wide and 6 feet long and about 1 inch thick. The wooden tablet is carved, typically by the men, to reveal raised motifs or designs. The u’a is then laid on top of the upeti, and rubbed with brown dye and powdered earth clay to reveal the intended design of the tablet.

Before carving tools were available, an upeti was originally made from sitting mats made from large pandanus plants (large thick leafy plants used for weaving mats). These upeti-mats were approximately 4 feet wide and 8 feet long. On top of the upeti-mats women would lay coconut frond midribs and tie them to the mat to create raised motifs. These raised patterns were transferred to the surface of the siapo cloth when rubbed with dye soaked swabs and powdered earth clay.

![Figure 2.2: Example of a siapo elei cloth rubbed over a wooden upeti to reveal distinct Samoan siapo designs.](image)

Black or brown dyes were then used to emphasize design motifs by over-painting certain designs after they were imprinted. Siapo elei pieces were originally used for clothing, bedding, curtains, burial shrouds, and ceremonial dress (Meredith, personal communication, February,
2010). A sample of the *siapo elei* is shown below. This *siapo elei* was imprinted with an *upeti* and overpainted to emphasize designs chosen by the *siapo*-maker.

![Image of siapo elei](image)

*Figure 2.3: Example of traditional siapo elei.*

The second type of *siapo* is the *siapo mamanu*. *Mamanu* is Samoan for patterns or designs. A *siapo mamanu* is created by freehand painting Samoan design motifs on bark cloth without the use of a wooden design tablet or *upeti*. A *siapo mamanu* is distinctly different than *siapo elei* because *siapo*-makers incorporated the use of colored dyes not commonly found on older *siapo elei* such as red and yellow dyes, to further emphasize those designs. Another difference between *siapo elei* and *siapo mamanu* was the latter type were often glued on flat pieces of plywood to be used as wall hangings. By mounting them on large wooden boards *siapo*-makers hoped these *siapo mamanu* would look similar to large art paintings enticing American and European tourists who were looking for Samoan handicrafts as souvenirs, to buy them.

As seen in the *siapo mamanu* below there are several design motifs of different colors that are repeatedly painted on the *siapo*. Samoan motifs are geometrical shapes that represent
environmental objects. These are repeatedly drawn and painted by reflecting, translating, or rotating those designs or shapes throughout the *siapo mamanu*. It was the geometrical nature of this freehand painting method that made me decide to use this as a topic for research for this first course in Project MACIMISE.

Figure 2.4: *Siapo mamanu* example (approximately 4 feet wide, 6 feet long). Source www.siapo.com

**First meeting with a cultural expert on siapo painting.**

To learn about the *siapo* painting process, my Project MACIMISE colleague in American Samoa, Tauvela Fale and I, decided to seek the help of a *siapo* expert. We scheduled a meeting with *siapo* expert, Regina Meredith in the spring of 2010. During our first meeting the *siapo* expert showed us several samples of *siapo* from three different island cultures—Samoa, Fiji, and Tonga. She asked us if we noticed the different distinctive styles in patterns, colors, and shapes used in each. In the Tongan *siapo* called *ngatu*, the color of the brown dye used was darker than the Samoan *siapo* because they used brown dyes from a different plant source than Samoan *siapo*. The *ngatu* cloth was also thicker than the Samoan *siapo* as a result of the process used to flatten the bark to make the cloth. In the Fijian *siapo*, called *masi*, the use of black dye was more prevalent and the design elements and lines were smaller and closer together than those found in
the Tongan *ngatu* or Samoan *siapo elei*. See a sample of Tongan *ngatu* in Figure 2.5, and one of the Fijian *masi* in Figure 2.6 below.

![Figure 2.5: Tongan *ngatu* sample.](image)

![Figure 2.6: Fijian *masi* sample.](image)

When Meredith explained that the processes of making a *siapo* cloth were similar in each island culture with a few differences based on the availability of resources and personal preferences, I was intrigued and decided to learn how to process the *siapo* cloth. At this point I realized that this was becoming more than mere research for a mathematics presentation but was going to become an enriching cultural learning experience.
Later, I decided to ask my father, who I consider the most knowledgeable person I know when it comes to Samoan culture, language, and especially Samoan plants, to help me learn more about the *siapo*-making process. He taught me how to process the bark of the *u’a* (paper mulberry tree), and collect the dye from the *o’a* (bishop wood) tree which will be discussed later.

After that first meeting with the *siapo* expert, I began making preparations to paint my first *siapo*. I was excited. However in each exciting moment I kept asking myself the same question, “What mathematics was a *siapo*-painter using at this stage in the process?”

I remembered feeling overwhelmed with the awareness of the mathematical skills and knowledge and thinking it took to paint a *siapo*. The mathematical awareness heightened as I figured out how to find the center of a *siapo*, make the first lines and motifs repeat themselves in rigid transformations, and finally color coordinate the painting. What started as a project that studied the symmetry and rigid transformation of the shapes in a *siapo* painting became a richer mathematical experience. The actual act of making or constructing something that was full of beautiful symmetrical motifs took a lot of calculation, measuring, estimating, trial and error and problem solving. This awareness of rich mathematics came to me when I was creating and constructing a *siapo* design. It made mathematics come alive for me. It made mathematics feel real. This was an important feeling for me because it was one that I try to exemplify in my teaching today. When we construct and solve problems in real contexts it makes mathematics motivating, fun, real, and exciting. I also realized that my cultural knowledge of *siapo*-processing kept growing the more I became involved in this assignment. More about the power of doing mathematics will be discussed in the final chapter.

As I learned more about the *siapo mamanu* I began wondering about the process of making a *siapo elei*. After some research at the University of Hawai’i library and an examination
of online photos of *siapo* in different time periods, I found a distinct difference in the intricacy of the designs between a *siapo mamanu* and *siapo elei*. The *siapo mamanu* design motifs were smaller, which meant there were several more shapes painted on the same area of a *siapo mamanu* versus a *siapo elei*. The *siapo mamanu* had designs that emphasized the importance of rotational symmetry. If there was a distinct difference in appearance and process then there must be a difference in the mathematical thinking involved as well. One of these differences I suspected in the *siapo mamanu* was that number of patterns and size of shapes needed to be calculated more precisely in order for the design to be symmetrical.

After conducting the research for the *siapo* lessons, I put together a PowerPoint presentation for our first course with Project MACIMISE. I shared information about the art of *siapo* painting and the rich cultural knowledge that I had learned. I also shared how symmetry and nonstandard measurements were prevalent in the *siapo* art form. Further, I explained how a *siapo* artist had to make decisions about creating the symmetrical nature of a *siapo mamanu* by repeating the motifs through reflecting, rotating, or translating those designs throughout a *siapo mamanu*.

What I realized during this presentation was that I was able to speak from my own personal experiences and explain the thought process more clearly than if I had only observed or read about the process.

**The production of culturally-based mathematics units for Project MACIMISE.**

Once my MACIMISE colleague Tauvela Fale and I had completed our presentations for the first course we discussed using the *siapo* presentation and research to help us create the fourth grade, culturally-based mathematics lessons that were required of us by Project MACIMISE. We then decided to use the local mathematics standards for the American Samoa
Department of Education (ASDOE) to locate applicable standards that would help us incorporate these lessons into the existing elementary mathematics curriculum.

We found fourth grade mathematics content standards that had applicable skills and knowledge that could be learned by performing this cultural practice. We wrote a five-day unit that contained five individual lessons on *siapo mamanu* designing and painting and submitted these to Project MACIMISE advisors and principal investigators for piloting and testing in our local schools.
Chapter 3

Research Design and Methodology

As part of our work with Project MACIMISE we were afforded the opportunity to earn a master’s degree or a doctorate in education with the University of Hawai‘i. I along with nine other doctoral candidates in Project MACIMISE identified topics for our dissertation research and selected doctoral committee members to oversee the dissertation work. My dissertation ideas developed and changed several times over a span of five years and these changes allowed me to develop my ideas and skills as a researcher. I also grew to understand the importance of research helping define who I was.

According to Mooney (1957), “Research is a personal venture which, quite aside from its social benefits, is worth doing for its direct contribution to one’s own self-realization” (p. 155). I have often felt the need to do research that helps me improve my work as a teacher. Part of the improvement process has been to acknowledge that I need to understand my motives for teaching and how children learn. Mooney (1957) reminds us that our research is very much a part of who we are. The following is a discussion of how my research ideas developed into this dissertation and shaped the teacher I am today.

How my dissertation ideas developed and changed over time.

In 2010, after our first research course with Project MACIMISE, I began to think of ideas for a dissertation. A year later I met with my dissertation chairperson, Dr. Neil Pateman, an instructor with Project MACIMISE, and discussed ideas with him. My original dissertation idea was to explore the field of ethnomathematics by developing culturally-based mathematics
lessons for grades one, four, and seven, as required by Project MACIMISE, and teach these lesson in elementary classrooms in American Samoa. I was going to conduct a self-study of my experiences planning and implementing those lessons. However, I did not have my own elementary classroom at the time because I was working with the University of Hawai‘i Cohort Program in American Samoa. Finding the time to do this with a busy schedule was proving difficult.

Later that same year, I decided to tweak the original dissertation idea and co-teach the lessons with teachers who were teaching in a grade one, four, and seven classroom or have three teachers one in each of the following grades one, four, and seven teach those lessons themselves. In the latter case I would then serve as a research observer collecting case study data on the teachers’ attempts to implement the lessons. However by the time I had finished developing the three lessons with my Project MACIMISE colleague Tauvela Fale in 2012, I had already moved to Utah. At that point I was distracted with the big move as well as discouraged because my ideas weren’t coming to fruition.

I remembered emailing the late Dr. Sandy Dawson, Project MACIMISE principal investigator, on September 23, 2011 requesting to withdraw from Project MACIMISE. He sent a brief reply to that email, “Sorry your request is not accepted! ...we can work out the dissertation and research at a later date when your situation in Utah becomes clearer” (Dawson, personal communication, September 24, 2011). This proved to be such a powerful statement and confirmation of his trust that I would continue to be supported and that I didn’t need to worry about the pressures of missed opportunities.

In the fall of 2012, after the culturally-based mathematics lessons for Project MACIMISE had been written, I was encouraged by my doctoral committee members to seek help from
teachers in American Samoa and distribute the lessons to those who might be interested in teaching these types of units. I would require these volunteer teachers to video record themselves teaching the lessons, take field notes on their thoughts about the lessons, and send me samples of student work so I could analyze the teachers’ perceptions of teaching culturally-based mathematics lessons in American Samoa. This was all to be done while I continued working in Utah.

In the summer of 2013 I flew to American Samoa and planned a face-to-face meeting with 15 teachers, who had expressed interest in helping me. I discussed the dissertation research idea with them and passed out the units. They all signed consent forms and were given instructions on data that they were to submit. It seemed like a promising endeavor at the time, yet I received only a single reply by the end of fall semester. I realized that part of the difficulty of this research approach was that I relied solely on the teachers’ abilities to collect all the data on their own and send it to me via email. The other difficulty was my inability to consistently follow up with teachers by phone or email to check on their status and check on updates. After receiving too few responses from teachers I had to abandon this dissertation idea.

A few months later, Project MACIMISE was able to assemble all the MACIMISERS at the annual NCTM conference held in New Orleans in the spring of 2014. It was there that I sat and met with Dr. Dawson while we talked about my dissertation data collection failures. At that time I was struggling to keep the focus of the dissertation on ethnomathematics and at the same time have direct contact with research participants.

Prior to the meeting in New Orleans, I had spent two summers working part-time in American Samoa in 2012, and 2013 teaching culturally-based mathematics lessons to inservice teachers. I talked with Dr. Dawson about those experiences and he had a lot of encouraging
words about his interest in the culturally-based mathematics lessons I had been teaching. He then
told me that my culturally-based lessons could be used as a topic for the dissertation. His parting
advice to me on the last day of the conference was to “write, write, write, and just write anything
that comes to mind regardless of its place in a formal dissertation, you need to just get your
thoughts on paper. Write about your experiences in American Samoa in 2012 and 2013 and share
your story.”

Little did I know that that trip to New Orleans would be the last time I spoke face-to-face
with Dr. Dawson. His sudden passing in January 2015 caught all the Project MACIMISE
participants by surprise as he communicated with all of us via email right up the week before he
passed away. My doctoral studies had finally taken a positive turn in direct relation to his
patience and support for me and my struggles. He had just guided me on the right path and
helped me pour out my story on paper without worry about structure or purpose.

So I contacted my doctoral chairperson, Dr. Neil Pateman, and told him of the new idea
and he gave me his full support. My new dissertation topic would now be based on lessons I
taught to inservice teachers in American Samoa in 2012 and 2013. Because I was able to travel
back and teach culturally-based lessons again in 2015 while I was working on the dissertation
my doctoral chairperson and I decided to include those experiences as well. These lessons
provided rich experiences in teaching culturally-based mathematics lessons that were developed
as part of Project MACIMISE and became the foundation and the launching point for this study.
Research Paradigm

Social and cultural theories of learning.

Understanding my place among researchers in the field of mathematics education I needed to reflect on my ontological views as these pertain to mathematics education. Therefore I attempt to answer the questions “How do we learn mathematics?” and “What affects how we learn mathematics?” Psychologist Bandura (1997), the father of social learning theory, suggested that we learn from a social model (e.g. a parents or a teacher) in a process he called observational learning. We watch how our parents, teachers, siblings, and friends at school act, and we learn from it. How this plays out in a mathematical learning environment, whether with students and teachers in a mathematics classroom, or a mom and son learning to round cents to dollars in a store, will depend on the aspects of the particular interaction in the social environment.

In addition, socioculturalist Vygotsky (1978) suggested that these social interactions have much to do with cognitive development. Vital learning and cognitive development by children happen when that child is engaged with a skilled mentor. A skilled mentor models or demonstrates certain behaviors or verbal cues that will help the child learn, and this is called cooperative or collaborative dialogue. Children then attempt to comprehend the mentors behavior or verbal cues and internalize the stimuli and use it to gauge their own actions. In a mathematical environment this further emphasizes teachers’ roles in daily classroom practice as well as roles of parents in helping develop children’s understanding of mathematics concepts. It emphasizes the importance of language and social interactions between adults and children as well as children and their peers.

Aspects of interaction in the social environment that are of particular importance in this study will be social interactions between teacher and students during mathematics lessons
mediated by words written or spoken during those interactions. According to Lerman (2001) educational researchers can take a broader look at sociocultural learning by considering both language and discursive practices in the mathematics classroom. Furthermore these “interactions should not be seen as windows on the mind but as discursive contributions that may pull others forward into their increasing participation in mathematical speaking/thinking…” (p. 89).

As important as it is to focus on social learning theories it is also important to realize other factors when considering how students internalize environmental stimuli. Hence a second learning theory will be considered.

**Constructivism.**

In order to continue answering the questions, “How do we learn mathematics?” and “What affects how we learn mathematics?” I propose a look at constructivist theories of learning. Learning theorists, for example, Cobb and Steffe (1983) and Kilpatrick (1987), who work in the field of mathematics education, support the theory that people generate meaning or understanding from their ideas and their experiences. According to Lerman (1989, p. 211), constructivism consists of two hypotheses:

1. knowledge is actively constructed by the cognizing subject, not passively received from the environment, and
2. coming to know is an adaptive process that organizes one’s experiential world; it does not discover an independent, pre-existing world outside the mind of the knower.

The first hypothesis means that the act of constructing conceptual knowledge from environmental stimuli is twofold. First we select bits of information or stimuli and then either accept new ideas or rework old ideas to accommodate new ones. The second hypothesis
maintains that the location where knowledge is created is within the mind, which mediates sensory input and builds knowledge that remains in the mind. This does not deny the existence of a real world within which we live - just that the only way we can know that world is through our senses.

According to Jones and Brader-Araje (2002), the relevant perspectives of constructivism are, “… personal constructivism as described by Piaget (1967), social constructivism outlined by Vygotsky (1978), radical constructivism advocated by von Glasersfeld (1995), constructivist epistemologies, and educational constructivism (Matthews, 1998)” (para. 5).

Furthermore they propose that there is a common thread that runs across several perspectives of constructivism, which is “the idea that development of understanding requires the learner [to] actively engage in meaning-making” (para. 6). Students should therefore actively participate in the mathematics classroom because students learn mathematics through their actions on materials which is why manipulatives are so important. Student’s actions on objects become internalized as data from which they generate understanding. As a STEM teacher I constantly focus on the need for participation because my experience shows that students learn effectively by participating and engaging in conversation about their experiences.

As a teacher, I am most interested in constructivist philosophies with applications in the field of education with further emphasis on its impacts on my educational pedagogy as well as my personal understanding of constructivism as a learning theory. Matthews (1998) stated, “Educational constructivism of the personal variety stresses the individual creation of knowledge and construction concepts”, while, “Educational constructivism of the social variety stresses the importance of the group (be it the immediate classroom or the wider culture) for the development and validation of ideas” (p. 3). This helps me consider the roots of both how teachers and
students construct their own personal meaning, and how they do it through their interactions within the classroom.

However I am cautious not to assume that when teachers attempt to help students construct knowledge by providing certain classroom experiences there is some way to accurately gauge or measure the learning that was constructed. Perhaps as Matthew puts it, it will be in the nature of “Vygotsky’s work in linguistics and language acquisition” (p. 3) that gives teachers the best tools to understand what has been learned by observing students interactions or drawings, listening to students discussions, and finally, reading their writing.

In terms of using the constructivist lens as a mirror to view my own meaning construction of research participants’ meaning-making during our interactions and discussions I offer Naylor and Keogh’s (1993) definition of constructivism, “…learners can only make sense of new situations in terms of their existing understanding. Learning involves an active process in which learners construct meaning by linking new ideas with their existing knowledge” (p. 93).

I realize that meaning I construct from my experience studying research participants will be filtered by my existing understanding. Therefore I declare that what you are about to read is narrative research heavily filtered through my ontological framework as stated here.

Using both a socio-cultural and a constructivist lens.

In the voyaging days of Samoa, canoe builders had to make sure that the planks of the hulls of large voyaging canoes called alias, fitted perfectly together to support the weight of the passengers and cargo as well as keep seawater out. Although the planks were different widths and lengths, they were crafted by the canoe builder to fit snugly together. Each one served a critical role. The Samoan proverb that stems from that action is, “Ua fetaui lelei fola o le alia”—
the deck planks of the voyaging canoe fit together well—this helps describe how I view these major learning theories as planks fitting together to form the basis of how I think about the ways we learn.

According to Simon (2009), in his review of theories in mathematics education, constructivism and socioculturalism each differ in terms of framework and application, but each theory can help support a single researcher’s different views of how we learn. The theoretical framework stated above helps define the tools and lenses with which I will view and share the data in this research study. As Simon stated, “Theories can be thought of as lenses. When one looks at a situation through a particular theoretical lens, some phenomena are prominent, whereas others are not” (2009, p. 482).

Why a Narrative Research Design?

“One theory in educational research holds that humans are storytelling organisms ... learners, teachers, and researchers are storytellers and characters in their own and other’s stories” (Connelly & Clandinin, 1990, p. 2). As an educator and a father I am always asking my students and my children why something happens and ask them to explain what is going on. I ask them to tell me their stories. In turn I love to explain and share my own stories with them. It is in the telling or explaining these stories that I hope we can communicate with each other what we know.

Connelly and Clandinin (1990) suggested that a narrative research design allows researchers to ask questions and explore the meaning behind those questions. It gives them a tool to describe occurrences and research participants’ thoughts and ideas in a storytelling format. Narrative research design allows me to narrate a story of experiences of individuals connected by
time and place. This design is an important part of educational research because it places emphasis on teacher reflections, teacher knowledge, and it helps teachers voice their individual experiences.

This research design is ideal to help me explore the phenomenon of both teachers’ perceptions of ethnomathematics and its applications in American Samoa. Bruner (1990) suggested that creating stories is a human response for making meaning or comprehending events in our lives. He argued that stories are often based on puzzling, surprising, confusing or frustrating episodes in our work. I used these strengths of narrative to explore teachers’ thinking, attitudes, and desires as we experienced ethnomathematics as a practice. “Education and educational research is the construction and reconstruction of personal and social stories” (Connelly & Clandinin, 1990, p. 2). Narrative research design also lends well to the research of experiences of indigenous people and their own knowledge and perceptions because it takes stock of the importance of firsthand knowledge, and it aims at retelling our own teachers’ experiences and attitudes about ethnomathematics. I close this section with the words of Bell (2002):

Narrative inquiry rests on the epistemological assumption that we as human beings make sense of random experience by the imposition of story structures. That is, we select those elements of experience to which we will attend, and we pattern those chosen elements in ways that reflect the stories available to us (p. 207).

**Developing Questions to Guide the Study**

I have always been interested in my students’ experiences and mathematical awareness during mathematics lessons. What has helped me sift through layers of understanding has been
listening to their stories and sharing these with colleagues or future students. This dissertation’s aim is to describe and analyze what I have learned about the way my students experienced learning mathematics and to tell that story. In this study I am the mathematics teacher and the students are inservice teacher participants during three summers of mathematics course work in American Samoa.

The context therefore is triangulated by my experience as a mathematics learner and teacher, my experience with the field of ethnomathematics and Project MACIMISE, and finally the experiences of teacher participants and cultural experts during culturally based lessons in 2012, 2013, and 2015. This study therefore hopes to pin the ontological and epistemological thoughts about ethnomathematics experiences in a narrative research study of culturally-based mathematics lessons, teachers’ reactions to those lessons, and the researcher’s narrative study of himself connected to those experiences. The research questions that this dissertation seeks to answer follow.

**Research Questions**

1. What did teachers learn from the culturally-based mathematics lessons?
2. What did I learn from teaching and participating in the culturally-based mathematics lessons?
3. How have my experiences with the culturally-based mathematics lessons influenced my view of the field of ethnomathematics?
Sources of Data

I was able to create a narrative story of my experiences by taking a close look at all the data I had collected before during and after the lessons I taught. Each of the data sources fits into one of three main categories: written words, spoken words, and visual data.

Written data.

Sources of written data were collected from the lessons in 2012, 2013, and 2015. In no particular order of importance, these consist of:

- course syllabi,
- daily lesson plans,
- teaching notes written during each lesson,
- personal teaching reflections written after each lesson and after the course was taught,
- journals from teacher participants,
- teachers’ written answers to problem solving questions,
- transcribed audio recording of teacher participant discussions during the lessons and cultural practices that were representative of others,
- a newspaper article featuring one of the lessons,
- personal email communications between myself, teacher participants and Project MACIMISE participants,
- teacher participants’ comments and posts and instant messages on Facebook, and
- Five transcribed interviews from five separate 2012 participants conducted in July, 2015.

Spoken words.

I made audio recordings of:
• teacher participants’ discussions during cultural practice performances which were transcribed to help me capture and compare teachers reactions to lessons,

• meetings with doctoral committee advisors which were not transcribed but used as references and clarification,

• Project MACIMISE meetings and conversations with participants which were not transcribed but used for references,

• conversations with teacher participants and University of Hawai‘i colleagues, as well as conversations with my wife about the lessons which were not transcribed but used as reference.

**Visual data.**

Photographs were taken of teachers during each lesson together with photographs of their finished and unfinished cultural products. These photographs form an important part of the text of this dissertation.

**Analyzing narrative data.**

Narrative analysis for this dissertation fell into two main categories. One was thematic content analysis and second was visual analysis. Narrative researchers examine artifacts of social communication. Typically these are written documents, or transcriptions of oral recorded communications. Broadly defined, content analysis is, “any technique for making inferences by systematically and objectively identifying special characteristics of messages.” (Holsti, 1968, p. 608). Visual analysis is the ability to use visual images to capture the feelings, emotions, perceptions, and thoughts of participants that may be brought to mind by still images. It is the researcher’s job to interpret these feelings and thoughts in the creation of a coherent story.
“And just as interview participants tell stories, investigators construct stories from their data” (Reissman, 2008, p. 4). As I reviewed data from the lessons I constructed the story of my experiences from teacher dialogue, photographs, and audio recordings of events that took place in American Samoa. I have told my story and that of the teachers as we collectively experienced ethnomathematics in practice. According to Lieblich, Tuval-Mashiach, & Zilber (1998) narrative materials may be processed analytically by breaking the text into relatively small units of content, “[T]he narrative story is dissected, and sections or single words belonging to a defined category are collected from the entire story or from several texts belonging to a number of narrators” (p. 12).

Data were analyzed by coding selected passages from transcribed interviews, field notes, reflections, as well as teachers’ journals. Dissecting the common themes and ideas from those texts was an important part of determining big ideas that build the last chapter of this dissertation.

Samoan orators are those who perpetuate Samoan language and tradition and value the power of words and stories that are passed down from one generation to the next. In a society where oral traditions are still a powerful vehicle to pass on knowledge and wisdom, culture and its values, a Samoan proverb reiterates their philosophies, “e pala le ma’a ae le pala le upu - a rock might decay but words never will.” I have translated the teachers’ and my experiences with culturally-based mathematics lessons into a story that is worth reading, this story and its message are meant to be perpetuated.
Limitations of this Study

Descriptive studies such as this cannot offer predictions nor is it possible to generalize any of the outcomes to other situations. Such studies may not claim representativeness. Indeed, it is not possible to claim that a similar group of teachers in Samoa would react similarly to the same lessons. This study records a unique set of circumstances generated to investigate questions whose answers were best found by applying narrative research, and that apply only to the participating teachers and myself.

Some readers may believe that an associated limitation is that, as the researcher, I was also a participant in the study. Guba and Lincoln (1981) reminded us of “unusual problems of ethics” (p. 378). Thus, my role required me to seek to keep such potential problems in mind, during my conduct of the study, and my analysis. For example, I relied on using multiple data sources as often as possible to support the conclusions drawn from the impact of the lessons. I interviewed students from earlier years as a check of my notes of lessons taught earlier.

I should like to end this section on a positive note. A descriptive study such as this may allow readers to recall from the narrative sufficiently similar situations from their own experiences, so that readers may well learn something relevant to their own context (Stake, 2005). This is the real strength of such qualitative studies.
Chapter 4

Culturally-based Mathematics Lessons in American Samoa

In the span of three summers, 2012, 2013 and 2015, I taught a total of five separate culturally-based mathematics lessons in American Samoa. I taught the first, second, and third of the five lessons in 2012. I taught the final culturally-based mathematics lesson twice, once in 2013 and once in 2015. I labeled this final lesson as the fifth. This chapter provides a detailed chronological narrative description of the culturally-based mathematics lessons that were taught. This narrative hopes to capture (a) the research and cultural relevance of each lesson, (b) teachers’ experiences in those lessons, (c) my personal reflections on highlights and impacts of those experiences on my learning and teaching of mathematics and finally, (d) my growing understanding of the field of ethnomathematics.

Summer 2012

In the summer of 2012, I left southern Utah to go to American Samoa to teach a mathematics course for the University of Hawai‘i Cohort Program. The mathematics course was an introduction to mathematics for elementary teachers, intended to help inservice teachers deepen their understanding of mathematics concepts such as number sense, number operations, geometry, measurement, and algebraic thinking. The students for the course were 18 early childhood education and 4 elementary inservice teachers earning their bachelor of education degree in elementary education.

At that time I had been involved with Project MACIMISE for two and half years. When I planned my course material and my syllabus for the course, I thought about how rich my experiences were with ethnomathematics during Project MACIMISE so I decided to use
culturally-based mathematics lessons in my course material. The three culturally-based activities for the mathematics lessons were, (a) making a *salulima* (Samoan handheld broom), (b) weaving an *ato launiu* (a Samoan coconut frond basket), and (c) exploring ratios of ingredients in *meaʻai* Samoa (Samoan culinary practices).

**Who were the teachers?**

A brief description of the participants in the culturally-based mathematics lessons in the summer of 2012 follows:

- All participants were inservice teachers working towards their bachelors of education degree with the University of Hawaiʻi cohort program
- All participants spoke and wrote in both English and Samoan and were of Samoan ethnicity
- Eighteen of the participants were early childhood educators working with students from 3-4 years of age, while four of the participants taught elementary grades ranging from grades 1-8. There were three males and 19 females.
- All participants lived most of their lives in Samoa or American Samoa.

**Lesson 1: Salulima lesson.**

One week before I left Utah to begin teaching the four-week course in American Samoa, my wife and I drove to Walmart in St. George, Utah, where I live, to do some food shopping. While driving from the store I remembered asking my wife, “What would make a good culturally-based mathematics lesson? What cultural activity could I use to teach mathematics?” At that moment we passed a palm tree by the side of the road and my wife looks up at it and asked, “How about if they make a salulima (hand-held broom made from the midribs of the
leaflets of a coconut frond)? They could count the number of tuaniu (midribs) they would need to bundle to make a good salulima.” I immediately thought how interesting that would be for a culturally-based mathematics lesson and began a mental checklist. Below is a recollection of what I was thinking and questions I asked along with my answers to those questions.

1. Was the task of making a salulima an authentic Samoan cultural activity? Yes I remembered my aunty Sina making a salulima and remembered most Samoan women making these while I was growing up in American Samoa.

2. Secondly, were the authentic cultural materials readily available and cheap? Yes, coconut fronds were easy to acquire and didn’t require any money.

3. Third, did the process of making the salulima involve mathematical skills and knowledge that I was trying to teach during the course? I began to list the following in my head: (a) a salulima maker needed to estimate the number of midribs needed for one salulima, and (b) they bundled them in groups by size or number of midribs. Yes, the salulima-maker had to estimate and calculate. These were mathematics concept teaching goals for the course.

4. Fourth, was this a culturally-based mathematics lesson that participants could then teach in their own classroom settings (not just something that made a fun activity)? Yes, I felt that it was useful and transferable to participants’ classrooms. I felt this was important because I wanted to help teachers learn strategies that they could take into the classroom and try.
5. Fifth, was the cultural activity something that I could perform myself so that it was done in a traditional manner? I remembered helping my aunties make *salulima* when I was younger and I knew that I could perform the task, and explain it well.

So thanks to my wife’s brilliant suggestion, I decided to develop a lesson on making a *salulima* and then decided to use a question to guide the activity: “How many midribs does it take to create a *salulima*?” This lesson was then taught on June 12, 2012. A *salulima* is made from the *tuaniu* of a *launiu*. See Figure 4.1 below of a completed *salulima*.

*Figure 4.1*: An image of a *salulima*. Used with the permission of Treanna Faagau-Noa.

This durable lightweight traditional broom is usually made by the women in the village to sweep both heavy and lightweight particles such as leaves, dust, and rocks inside or outside the homes. Each *salulima* uses approximately 100-200 *tuaniu*. Midribs are the thin hard part of the individual leaflets connected to the coconut frond. The midribs are as thin as a spaghetti strand but as long as 3–4 feet.

On the day of the lesson teachers brought in *launiu* to complete the activity. The teachers were asked to think about the possible mathematics that a Samoan woman would think about
when she produced a *salulima* for the family’s use. Then I asked the teachers, how many individual midribs would it take to make one *salulima*?

As students began to strip the leaflets on the launiu to expose only the midribs a small group discussion followed, focusing on what they thought determined the number of midribs for one *salulima*. When we discussed the sizes and measurements of a *salulima*, factors that students conjectured could influence the number of midribs and the size of the *salulima* included the size of the individual midribs available, where the *salulima* was to be used, and the users personal preference. I now highlight the ensuing discussion.

1. Some teachers thought that one of the factors influencing the number of midribs used was the *salulima*’s primary use (whether it was used inside to sweep small particles or outside to sweep larger ones). If it was used outside, a *salulima* typically contained more midribs so that it could handle the task of sweeping large particles such as large or small leaves and small rock particles. If it was used inside the house it would probably have fewer midribs.

2. A second factor that teachers debated was that some varieties of coconut tree had fronds with thinner, less rigid midribs, which would not be suitable for creating a *salulima* that was used to sweep larger particles such as rocks or leaves outside the house.

3. One group of teachers stated that the number of midribs needed to create a *salulima* might depend on the personal preferences of the *salulima* maker. They said that some *salulima* makers have a particular preference for larger or smaller *salulima*.

4. Some teachers conjectured that the number of midribs used might depend on the availability of mature coconut leaves. If an abundant supply of coconut leaves were available then the *salulima* tended to be thicker and contain more midribs.
5. Yet other teachers argued that the number of midribs for one salulima was solely dependent on the maturity of the coconut leaf because mature leaves had thicker midribs therefore requiring fewer midribs per salulima.

6. And finally others felt that the number of midribs per salulima depended on the strength and size of the hand that was going to use it. If the salulima was going to be used by a child with a smaller hand then the salulima would have fewer midribs, but if it was to be used by an adult then it would probably have more. One student finally said that she would probably have salulima of different sizes in one household, one for the kids and one for the adults.

After our initial rich discussion on factors for the number of midribs I felt encouraged to propose more mathematical extension questions. Here are the extension questions that I asked:

1. How many coconut fronds would it take to produce one salulima?

2. How long it would take to make one salulima?

Teachers were asked to answer these questions and then I encouraged each group of teachers to come up with their own extension questions as they worked on performing the cultural practice themselves. See Figure 4.2 below.

*Figure 4.2*: Teachers discussing extension questions.
Teachers counting midribs and discussing possible extensions.

During the actual demonstration portion of the lesson teachers worked in groups of three to five to make a salulima. Teachers used this hands-on experience to answer the original question, “How many midribs would it take to make a salulima?”

Once teachers had completed the task and we had gathered all the data from other groups of teachers we realized that it took between 100-200 individual midribs to make an average-sized salulima. You could produce a single salulima from a single coconut frond and it took approximately one hour to create one salulima.

Then participants were asked to come up with mathematical questions themselves. As they recorded their questions, they were then asked to come up with their own solutions to each question they asked.

This also led to teachers asking questions about the Samoan language surrounding the cultural practice. There were instances when we made sure we were using the correct Samoan word for the actions of removing the leaflets. This correct use of language was emphasized by some of the older teachers. They also asked me how to translate the word circumference from English to Samoan. The consensus was to use the word, “lio”, which translates to “circle.” The lio could therefore be a large one or a small one or be comparative in size to other lio. A more recent discussion with my doctoral advisor led me to realize that it is unusual to use the word for the object to also describe a property of that object. Perhaps this is because there is no standard unit of measure to measure the circumference of an ato launiu or else the circumference of the ato launiu has little cultural significance. What was more culturally significant was that the ato launiu- makers made sure they crafted an ato that had the appropriate volume. However as I reflect on the practice, I can say that most ato launiu were in fact directly determined by the size
of the *lio*, that is, its circumference but only identified after the fact as having a large or small volume. I distinctly remember *ato launiu*-makers bringing the ends of the *launiu* spine together (as if you brought the ends of a piece of string together) to see if the circumference of the *ato launiu* was adequate. This must lead to a skill that the *ato launiu*-makers have that allows them to predict the volume of an *ato launiu* by determining the size of its *lio*.

We realized a simple counting lesson became a rich mathematical inquiry with a lot of mathematical concepts such as, subtracting, division, grouping, sorting, and measurement. It also became a rich cultural lesson with extensions into vocabulary building in both English and Samoan. For many of the teachers this activity helped expose the rich mathematical processes and thoughts that a person who performed a cultural practices had to have in order to successfully perform the task. Many teachers commented on how their perceptions of the mathematics concepts to be covered in this lesson was only “counting” but the lesson evolved to include so many other mathematics concepts.

Here are samples of the questions that teachers created in their groups during and after they made their own *salulima*.

1. What determines the amount of midribs to be used? Is there a standard number? Or is it the size of the bundle of midribs that determines the amount of midribs?
2. Is the final girth of the bundle of midribs where it is held determined by its use, or is that girth determined by the size of the hand that holds it? Are the number of midribs used to make a *salulima* determined by how heavy the *salulima* is? Is there a weight that is too heavy or too light?
3. How many midribs can one get from one *launiu*? Do different varieties of coconut tree have *launiu* with a different number of leaflets/midribs? Are there ones that are more
preferred because of the length, thickness, or rigidity of the midrib? What is the average number of midribs for each variety of launiu?

4. How many launiu would it take to make one salulima? Two? Three?

5. How long does it take to make one, two or three salulima? What factors determine the length of time it takes?

![Image of a group of people holding launiu leaves]

Figure 4.3: We display our completed salulima.

Lesson 2: Samoan Ato Launiu lesson.

This lesson explored the patterns used to weave the leaflets of a launiu to create an ato launiu. An ato launiu is a Samoan coconut frond basket. This cultural practice was selected to help teachers identify and describe patterns that existed in its weaving and braiding. I was also interested to see if the teachers could discover other mathematical skills and knowledge a Samoan might have used to create the basket. See Figure 4.5 below of an ato launiu and launiu.
Figure 4.4: Pictures of an *ato launiu* (left) and a *launiu* (right)

The *ato launiu* is usually made from a freshly cut *launiu* or coconut frond. It is used by both men and women for carrying and storing materials. Some materials they transported or stored were: breadfruit, taro roots, banana, or coconuts. The *ato launiu* could also be used to collect trash around the home to be composted, carry food from the cooking house to various families, or used for temporary storage of food. The one way it was not used was to store water as it was not without gaps or holes between the leaflets. The *ato launiu* however is a versatile, lightweight, and durable transporter for light or heavy loads. To create the *ato launiu* the *launiu* is split into two symmetrical sections along its spine. One *launiu* can produce two *ato launiu*. There is one basic plaited weaving pattern for all types of *ato launiu* but it is in the various braiding patterns that create the different types of Samoan *ato launiu*. These braiding patterns not only determine its shape but also determines its primary function and name.

1. *Ato fai meai*: The most common basket, used to carry or store cooked food, has a single or double braid that is straight across the bottom of the *ato launiu*.

2. *Ato lapotopoto*: This basket is used to carry raw materials and larger heavier loads and has a braid that is similar to a swirl.
The lesson began with all the teachers assembled in the classroom with their launiu as I asked them, “Who knows how to weave a Samoan ato launiu?” Only three of the 22 teachers responded that they knew how to weave a basket. I was not surprised to learn that few knew how to create a Samoan basket because it was a hard skill to master. The three ato launiu weavers shared how they learned to weave an ato launiu. Their responses were:

1. The first weaver said she knew how to weave an ato launiu when she was younger because her family used to deliver and sell local starch produce (breadfruit, bananas, taro) at the local market. They had to weave several ato launiu to carry all the produce to the market every weekend.

2. The second weaver said she knew how to weave an ato launiu because her family performed many Samoan cultural practices using an ato launiu and her parents taught her how to weave one.

3. The third weaver said there were very few men in her family and she was forced to do a lot of the traditional cooking that was usually left to the men. In order to transport the food they had to have ato launiu. She was shown how to make one by her aunty.

Those who said they did not know how to weave an ato launiu stated the following reasons for their lack of knowledge or skill.

1. Men in their family performed most of the cultural practices that required the weaving of baskets and they did not have to learn it.

2. People use the ato launiu less and substitute its use with modern containers for transporting and storing food or raw materials.

3. They were never exposed to nor taught the skill.
4. Some said they had observed parts of the skill and even attempted it once or twice but never mastered it.

I then picked up one of the launiu and asked the teachers if they knew how a Samoan would begin the process. We discussed that the launiu has two ends, the ulu (head) and the siusiu (tail). The tail is the tip of the launiu that extended away from the main stem and the head is the part of the launiu closest to the main stem of the coconut tree. This is an important cultural distinction because once the launiu is split in two the weaver makes sure they always start the weave at the ulu and not at the siusiu. This is important because of the way the leaflets of the launiu are facing and because the leaflets are more uniform in size at the base of the launiu than they are at the tail. My father Tauiliili Pemerika taught me this when I was younger and we discussed this the night before I taught the lesson to make sure I explained the cultural practice correctly. The following step-by-step demonstration of the splitting of the launiu and weaving portion was modeled in front of the class.

1. I split the launiu symmetrically from the tail to the head and made sure to identify each part again, the ulu and siusiu.

2. Starting at the ulu, I demonstrated the weave pattern by placing the first three leaflets in an alternating weave pattern.

3. Then I lifted portions of the three previously woven leaflets and inserted the next two alternating leaflets to form a plaited weave. Two more leaflets were alternated and inserted into the weave again. This was repeated until students were able to observe how each alternating leaflet was inserted into the previous woven leaflets. This woven pattern became the walls or sides of the basket.
4. When the desired depth of the sides or walls of the basket were achieved, leaving enough of the leaflets to braid the bottom of the basket, the woven pattern continued sideways or along the spine of the *launiu* until the weaving got closer to the tail or tip of the *launiu* or until the desired circumference of the basket was obtained.

At this point teachers were asked to gather their *launiu* and begin weaving. I had to make sure that teachers who needed more scaffolding were paired with experienced weavers. Then I walked around the room talking to and assisting teachers as well. Here are a few mathematical ideas that emerged from both my prompting questions, my observations, and comments made by the teachers about their actions.

*Mathematics concepts from the ato launiu weaving.*

1. One teacher related the alternating pattern of leaflets to odd and even numbers. When asked about whether the completed *ato launiu* had an odd or even number of leaflets teachers began to discuss this with each other. After some time, when I posed that question to the whole class more and more teachers discovered that there was always an even number of leaflets to make any basket regardless of size. As one teachers explained: “each *ato launiu* started with three leaflets, then we kept adding two more leaflets each time, so we get three plus two plus two plus two and then at the end of the *ato launiu* we connect it with one last leaflet.”

2. Then I asked teachers how the circumference of the basket was determined? Several teachers stated that it could be determined by: the maximum length of the spine that had usable and similarly sized leaflets of the *launiu*. 
Figure 4.5: Teacher begins the plaited weave of the *ato launiu* at the *ulu* or base of the *launiu*.

Figure 4.6: The two sides of the plaited weave are connected to form the circumference of the *ato launiu*.

Students were asked to take a break once the weaving was done, which took about an hour and a half, and I tasked my three experienced weavers to break the class in four groups so that we could demonstrate the braid when we returned from the break. As we worked on the braiding of our *ato launiu* I went around and had some discussions about patterns they were
recognizing in the braid or any other mathematical ideas that came to mind while braiding the

ato launiu.

The braiding of the ato launiu was a lot more difficult for the teachers than the weaving portion. Many of the experienced weavers and I had to finish braiding the ato launiu for several teachers or at least assist them halfway through This was not surprising to me considering my own experiences having difficulties remembering the pattern of the braid, knowing which leaves to incorporate and which ones came next. Here are some of the comments made by teachers and notes from our group discussions about patterns or mathematical ideas while they were weaving or braiding the ato launiu.

1. The weaving and braiding of the ato launiu was very difficult and was something that had to be learned over longer sessions. Participants realized they needed more practice.

2. Teachers did not feel that they could duplicate the whole process without assistance.

3. Teachers expressed that they were impressed with the skill and knowledge Samoans had in order to make such a complicated basket.

4. The braiding patterns varied between the weavers and teachers wondered if there were other braiding patterns that would work as well. Teachers also wondered how many different braiding patterns Samoans used.

5. They noticed that each pattern or braid determined
   a. the strength and aesthetics of the basket
   b. the size or volume of the basket
   c. the name of the basket and its purpose for example:
      i. a straight braid created an elongated basket which was typically used for transporting or storing cooked food.
ii. circular and spiral braids were used to carry bulky items and typically raw materials, for example, uncooked starches, coconuts, rocks, trash, and firewood.

Figure 4.7: Teachers with their completed *ato launiu*.

**Lesson 3: Ratios and proportions in Samoan culinary practices.**

The third lesson was a lesson on ratio and proportions during Samoan culinary practices. The lesson was inspired by Mene Tauaa who was the immediate supervisor over the 22 inservice teachers in the course. After sitting in one of the discussions on mathematical applications in cultural practices, Mene and other teachers began to suggest that there was a lot of mathematics involved in cooking Samoan food. After class that evening, Mene and I met and discussed the idea further. He suggested that the class take a trip to the local produce market and conduct an investigation on the ratios and proportions of ingredients used to make local Samoan culinary favorites. The main driving question for this lesson and field trip was, “What is the ratio between ingredients used to make local Samoan food dishes and what mathematics skills might be used when producing larger or smaller amounts of that dish?” Then teachers were encouraged to
develop the questions to specify which Samoan culinary practices they wanted to investigate. Here is an example of two specific questions teachers came up with before the fieldtrip:

1. What is the ratio of cups of coconut cream to the number of individual ripe bananas used in a local sweet delicacy called suafai (boiled ripe banana with tapioca and coconut cream)?

2. What is the ratio of one Samoan koko (cacao) bean pod to one cup of processed koko sold to make Samoan koko?

On the day of the field trip to the market, teachers were very nervous and embarrassed about asking complete strangers about their recipes. However all the teachers were able to complete their individual investigations that afternoon in an hour. After the interviews we met at the local spot where they sold panikeke (fried sweet dumplings) and teachers shared their experiences.

*Figure 4.8:* Teacher (right) at the market asking a local vendor (left) about ratios of ingredients in her faausi (taro, coconut cream, with caramelized sugar).
Teachers then took the time to write out their reports and submit the class assignment before they left the market. Teachers had both positive and negative feedback about the experience:

Table 4.1  
*Teacher Feedback from Samoan Food Market Field Trip.*

<table>
<thead>
<tr>
<th>Positive Feedback</th>
<th>Negative Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. They were impressed with how some vendors could estimate the individual ingredients of the food and give teachers ratios or recipes for them to report on.</td>
<td>1. Some of the vendors were not the ones that prepared the food and could not give any information regarding the ratio of food ingredients teachers were there to investigate.</td>
</tr>
<tr>
<td>2. They were impressed with how some vendors could estimate the individual ingredients of the food and give teachers ratios or recipes for them to report on.</td>
<td>2. Some vendors seemed annoyed at the questions and asked teachers to buy something before the vendors answered their questions.</td>
</tr>
<tr>
<td>3. Some vendors were very helpful and gave teachers more information than they needed.</td>
<td>3. Some vendors gave them information about their food the teachers felt was inaccurate and wondered if this was purposefully done to safeguard the vendors’ recipes</td>
</tr>
</tbody>
</table>

The second part of this lesson required each group to investigate ratios on its own. The field trip was a huge success and a great way to collect data. However, to truly have a cultural experience and really understand ratios in Samoan cooking, teachers had to prepare their own
food. So I created an assignment and asked teachers to: (a) work in groups of three or four, (b) decide on a Samoan dish, and (c) plan an in-class ratio investigation, demonstration, and presentation. Each demonstration was to be driven by a question to discover the ratios involved in that Samoan culinary practice. The following is a detailed description of four of the six groups’ guided questions, teacher feedback about each investigation, and highlights from each. Only four of the groups are reported here because I spent a greater part of demonstration lesson time with them.

**Ratio of coconuts to bananas.**

What is the ratio of the number of coconuts (to produce coconut cream) to an average-sized bunch of green bananas to make faalifu fai (green bananas boiled with coconut cream)?

*Figure 4.9: Fai, green bananas peeled and boiled*
Figure 4.10: Shredded coconut from eight coconuts used to produce coconut cream.

This group estimated that it would take about six to eight coconuts to make enough coconut milk to make faalifu fai (green bananas boiled with coconut cream) from a single bunch of green bananas. They also said that if this pot was full of starch then it would probably take up to 10 coconuts. They also noticed that many families would know how many coconuts to use based on the size of the pot and how much starch was in it. Each family designated a pot that they would become familiar with and discovered those ratios based on trial and error or some form of observational learning. I found out later that the pot belonged to a young man from the group and he already knew the ratio of coconuts he would need based on how many bananas his group members peeled and placed in the pot. I remembered overhearing him say that, “Six to eight coconuts should do the job.” This created two ratios, the number of coconuts to pot size, and the number of coconuts to quantity of starch in the pot. This same teacher said, 

In my family we know how many coconuts we need for that pot we always use to cook our food in, and that is how many coconuts I will get… I look at how full the pot is and I know for sure how many coconuts I need to scrape to make enough coconut cream for my faalifu (starch cooked with coconut cream). (Ratio and proportions lesson, June, 2012)

**Ratio of cucumbers to cans of mackerel to coconuts.**

What is the ratio of number of whole cucumbers to number of cans of pilikaki (mackerel) to coconuts (to make coconut cream) used to make salaki kukuma (sliced cucumbers with canned mackerel and coconut cream)?
This group of teachers wanted to figure out how much coconut cream it would take to make salaki kukuma. What was interesting about this group was that they started their investigation with a set number of cans of pilikaki, that is, four. Each can also contained at least four pieces of mackerel. First they emptied the cans of mackerel into their main serving bowl then they estimated how many cucumbers they needed to slice to have the consistency they desired. So out of the 10 cucumbers they brought they wanted to only use eight but ended up using all 10 because they didn’t want it to waste the remaining cucumbers. Then when they began husking all the coconuts they brought to make the coconut cream, they realized that in order to have the consistency they desired, they needed only six of the 12 coconuts they had husked. When the three key ingredients were all mixed together they felt that it had the right consistency so that their ratio of cucumber to mackerel to coconut cream was correct. So when asked about their ratios they reported that for every one can of mackerel you need about two cucumbers, and one or two coconuts depending on the size of each coconut or cucumber.

One of the most interesting comments they made during their report on ratios was that each cucumber and coconut was not the same size so you have to carefully estimate when using nonstandard sizes. But they also stated that estimating with nonstandard sizes is a skill that people acquire and that experienced Samoan cooks who almost always use nonstandard sizes
have those skills. Secondly, the idea of experience was brought up, and how hands-on experiences help people develop these skills. One lady in the group who was familiar with the recipe shared this idea with the other group members. One of the words that she kept saying out loud was “lava” which means enough. I remembered thinking to myself many months later that what she was expressing was that there is a point at which the ratio of the ingredients is just right. At that point she knew there was enough of each ingredient.

*Ratio of mo’oso’oi to coconuts.*

What is the ratio of *mo’oso’oi* (langlang) flowers to the number of coconuts (used to make coconut cream) in *faguu Samoa* (coconut oil scented with langlang)?

This group of teachers decided to investigate the ratio of the number of coconuts (used to make coconut cream) to the number of *mo’oso’oi* flowers you needed to make scented coconut oil. This type of coconut oil is made by boiling the coconut cream with the scented flowers. The residual oil is then poured in a large glass bottle to be used as lotion for dry skin and for massages. This group started with 6 coconuts and made their coconut cream first and then poured it into the bowl.

*Figure 4.12:* Teacher stirring *mo’oso’oi* flowers into a bowl of coconut cream.
Secondly, they took five handfuls of flowers, added them to the bowl, and began to stir the flowers in with the coconut cream making sure that each flower was coated with coconut cream. When asked why they stopped adding flowers when they clearly had a full bag of flowers and had not used them all, they said, “We want to make sure the flowers are all coated, so if you add too many flowers you are just wasting them.” Neither I nor the teachers could tell how many flowers were actually placed in the bowl at this point so we decided to just state the measure of the flowers by handfuls. So the ratio was five handfuls of flowers to six coconuts.

**Ratio of coconut water to cans of mixed fruit.**

What is the ratio of the number of fresh young coconuts (to get enough coconut water) to the number of 12-ounce cans of mixed fruit required to make coconut fruit salad?

This group of ladies planned to first investigate two separate ratios. The first was number of coconuts to cups of coconut water. So they began their investigation by cracking open the 10 coconuts they had brought for their demonstration and pouring the coconut water into two plastic containers. Then they used a measuring cup to measure how much coconut water yielded.

*Figure 4.13:* Average amount of coconut water in a young coconut (approximately 2.2 cups).
Figure 4.14: Teachers serving the coconut fruit salad.

After they measured the coconut water with the measuring cup) the teachers then emptied the contents into another container. They found that they had 22 cups of coconut water. The group then decided to find the average number of cups of coconut water in a single coconut by dividing the 22 cups of coconut water by 10 (the number of coconuts they used). This gave a ratio of 1 coconut to 2.2 cups of coconut water. When I asked a teacher in this group about the sizes of the coconuts and whether they all produced 2.2 cups that teacher responded by saying,

Well of course they are all different sizes and you will not get 2.2 cups of niu (coconut water) from each coconut so we should probably estimate that to about 2 cups of coconut water per coconut. And if you have a larger one you will get more than 2 cups and if you have a smaller one you will probably have less than 2 cups (Ratio and proportion lesson, June, 2012).

This group moved on to its next investigation which was to figure out the ratio of the number of cans of mixed fruit they would need to add to the coconut water to make coconut fruit salad. When they started they opened the five cans of mixed fruit they had brought and dumped
it into the large pot. Each can of mixed fruit contained about 20 ounces of mixed fruit in rich corn syrup. Then they took a spoon and scraped the coconut flesh inside each of the coconut halves into the pot. They had used the meat from all 10. Then they began to pour the coconut water into the pot, however, they did not use all of it in fears that it would make it too watery. When they felt they had the right consistency for their coconut fruit salad they reported that they used (a) the meat from all 10 coconuts, (b) five cans of mixed fruit, and (c) 11 cups of coconut water. The ratio of coconut meat to mixed fruit to coconut water was thus decided to be approximately 2:1:1. This group really liked using standard measurements to figure out their ratios. Teachers in this group were very meticulous when it came to expressing their ratios in accurate terms. Of all the groups they wanted to get the ratios represented in terms that they would express in a regular mathematics course. I could tell also that their group leader was a person who took accuracy very seriously and she encouraged her group to recheck their measurements several times before they submitted their report to me.

Figure 4.15: Teachers pictured together after completing different demonstrations on ratio and proportions in Samoan culinary practices.
We planned this to be the culminating activity for the summer 2012 course. Teachers decided to call it our Samoan day since we were emphasizing Samoan cultural practices in a festive demonstration similar to how local schools demonstrate cultural practices in what is commonly known as Samoan Day. Above Figure 4:15 shows the teachers in front of the banner used to commemorate this experience.

Summer 2013

In 2013, I was invited back to American Samoa to teach the same group of 22 teachers a second mathematics course for the University of Hawai‘i . This course was as an extension of the first course taught in 2012. Along with other course material on word problem situations, I decided to try a fourth culturally-based mathematics lesson. Because I had already tried three successful lessons with them, I searched for a cultural practice that I could use for a fourth lesson. I decided to use the art of *siapo*, the cultural significance of which is briefly introduced in chapter 2 and continued here.

Preventing for the *Siapo* lesson.

*Cultural background on siapo.*

The large *siapo* shown in Figure 4.16 is an example of a *siapo* used primarily for decoration. It was sold in the budding tourist market in the 1950's-1970's. It was a non-traditional *siapo* because was not made to be used for clothing, burial shrouds, floor covering, or drapery. There were also many other conventional uses for this cloth because it was the only type of cloth available on the island before Europeans brought cotton fabric to the islands. Although the making and use of traditional *siapo* clothing and tapestry still continue today I decided to study
the mathematics involved in the painting of non-traditional *siapo* used as wall hangings and tourist’s gifts.

*Figure 4.16:* Example of *siapo mamanu* with symmetrical designs. Source (www.siapo.com)

I decided to study the mathematics involved in this process because the painting of the *siapo mamanu* relied heavily on the *siapo*-makers understanding of mathematical concepts of symmetry and transformations. I thought that this cultural practice could be used to teach students an important mathematical concept described in the Common Core Mathematics Standards 4.G.A.3. for grade four. By the end of grade four these students are expected to, “Recognize a line of symmetry for a two-dimensional figure as a line across the figure such that the figure can be folded along the line into matching parts. Identify line-symmetric figures and draw lines of symmetry.” This standard allowed me to justify the use of this cultural practice as context to teach symmetry by identifying these in *siapo* paintings.

The painting on both non-traditional and traditional *siapo* consists of a specific set of traditional Samoan motif designs. There are 13-15 known motifs used in *siapo*. Figure 4.17 shows a sample of a motif design.
Siapo mamanu influenced by siapo artists

In 1960, a Samoan woman named Mary Pritchard, worked with several prominent *siapo* makers from the village of Leone, American Samoa, to create *siapo mamanu*. What was very impressive about their *siapo mamanu* was the style in arranging the traditional Samoan *siapo* motifs. The layout or the arrangement of the *siapo mamanu* was influenced by symmetrical designs found on stain-glassed windows on the local Catholic church in Leone. The stained glass windows had very symmetrical designs with many transformations of various shapes. Including these designs in the *siapo mamanu* art form allowed the *siapo*-makers to incorporate the use of rotational and reflective symmetry with Samoan motifs. Although all of the traditional motifs were still used there, was more emphasis on having the set of motif designs reflect, translate, or rotate somewhere on the *siapo* cloth.

This made the *siapo* designs more intricate, detailed and more symmetrical than traditional *siapo*. The mathematical concepts that were apparent in the designs of the non-traditional *siapo* were directly linked to the act of painting the designs and shapes on the bark-cloth. Mathematical concepts that stood out were the mathematical awareness of properties of lines, closed figures, angles, and symmetry.
I consulted with a local *siapo* expert, Regina Meredith, a locally renowned artist, who guided me through the process of making my first *siapo*. We worked for about a week creating a non-traditional *siapo* wall hanging. As we worked on the *siapo* making and drawing/painting processes I couldn't help but become aware of more and more mathematics that I had not noticed in the beginning. I realized that creating designs also involved awareness of area and distance. Of particular importance was finding the distance from one edge or corner of the *siapo* to the other. Another important idea involved “finding the center.” This was done by using the *siapo*-makers hand spans to determine the midpoint of both the length and width of the *siapo* board. Then the center of the rectangular piece was estimated using the intersection of those two points. When deciding which motifs to use I became aware that I was using various types of translation to repeat patterns. What impressed me the most was that there were so many mathematical concepts that I was constantly becoming aware of that I often felt overwhelmed. So after that one week I finished my first *siapo*.

**Lesson 4: Siapo.**

The *siapo* lesson focused on five cultural activities: (a) collecting the brown and black dyes need to paint the bark cloth, (b) gluing the *u’a* or *siapo* bark cloth to the 1 foot by 1 foot plywood board, (c) identifying and drawing traditional Samoan *siapo* motifs or design patterns, (d) investigating the mathematical concepts of symmetry and transformation of shapes evident on *siapo* samples, and finally, (e) painting the *siapo* bark cloth with the dyes using ideas of pattern repetition—slide, flip and turn.
Day 1: Scraping the o’a tree.

On the first day of the lesson we planned a field trip to my father’s land to scrape the bark of a large o’a (Bishop Wood) tree. The o’a trees inner bark is a moist fleshy bark that contains reddish brown sap. This sap is used as the brown dye and the base for the black dye. These two dyes are basic for all types of Samoan siapo. This was a significant day as we relied on an elder, Tauiliili Pemerika, my father, to help demonstrate how to collect the dye. This was my first experience collecting the dye for siapo painting. During the field trip, teachers gathered at my father’s house and brought a scraping tin, a large bowl, and tauaga (fibers used for straining dye).

Figure 4.18: Teachers scraping the outer and inner bark of the o’a tree using a scraping tin to extract dye.

Teachers’ most significant comments and questions during and after the o’a tree scraping field trip follow:

1. This was my first time experiencing this practice. I knew what siapo was and we have some in our family but I never knew which tree you used to get the dye
2. I now know where *siapo* gets its smell, it smells like the dye. The blank unpainted cloth does not have this particular smell.

3. This dye looks red. How does this make brown?

4. How much dye do we need for one *siapo*? I wonder how much dye is produced from a particular amount of scrapings and how much women collected for large traditional *siapo* cloths?

5. Are there other trees that Samoans use to make dyes?

*Day 2: Gluing the u’a to the 1 by 1 foot of plywood.*

On day two I had prepared and pre-cut half-inch plywood that measured 1 foot by 1 foot in length. I distributed the boards one to each teacher, who then sanded the edges and faces of the plywood to prepare its surface for attaching the u’a. Next I showed them one of the many large pieces of processed u’a or unpainted *siapo* bark cloth that I had gathered for this lesson. One aspect that amazed me and the teachers was that a large piece of *siapo* cloth about four feet wide could be produced from a single raw bark that was only four inches wide.

Teachers then selected pieces of u’a and cut out two pieces. They were asked to make sure they had a piece of u’a that was larger than the board so they could fold the edges over and glue them to the back of the board. To glue the *siapo* to the board, I boiled some water in class and added some cornstarch to form a gluey substance. This gluey substance was then rubbed all over the board and the u’a was then applied to the board with the glue.

The teachers most significant questions or comments during this part of the lesson represented the same type of inquisitive questions I had when I made my first *siapo*. They were all curious about the cultural process of making the *siapo* cloth.
1. What did Samoans use for glue in the olden days?

2. How long did it take women to make the siapo cloth?

3. How big was the tree used to make the siapo?

4. What does the u’a tree look like? Where does it grow?

![Image](image.jpg)

*Figure 4.19:* Students cutting the u’a pieces and gluing them to the plywood.

**Day 3: Identifying and drawing traditional Samoan motifs.**

On the third day teachers were introduced to the 14 traditional Samoan siapo motifs that were found on the website, http://www.siapo.com. These siapo motifs, along with their traditional names, are representative of things found in our Samoan environment, like the starfish, bird, pandanus leaf, banana pod, and centipede. Teachers were encouraged to identify and practice drawing the motifs on sheets of paper. They were also encouraged at this point to identify motifs they felt were aesthetically appealing as well those that might have some significance to them. Most siapo paintings were traditionally void of any emotional or personal link to their artists other than particular artists typically had favorite designs that they used in their siapo.
Figure 4.20: Example of Samoan siapo motif that represent a trochus shell. Source (www.siapo.com)


On the fourth day, I presented students with samples of actual siapo found on the website mentioned above. These were works from the era when the freehand siapo method or siapo mamanu was prevalent. These samples were great examples of siapo that contained three types of pattern repetition; translation (slide), rotation (turn), and reflection (flip). The ideas of slide, turn and flip were discussed in class and students were then asked to try to draw at two or three siapo motifs and to repeat the motif on paper using the three methods of repeated movement.
Days 5 and 6: Designing and painting of Samoan motifs on siapo bark cloth.

On the fifth day, students were given the opportunity to transfer their drawings from paper on to the siapo-covered plywood boards.

Teacher 1 discussion on Day 5 (designing of siapo drawing).

While talking to one of the teachers on the fifth day, I asked him to share his design idea. He quickly showed me a paper that had some sketches on it. He showed me the motifs he had chosen and then identified each one. He was making sure that he had at least 4 different Samoan siapo motifs because this was the first criterion. However, he seemed hesitant and kept shaking his head, so I asked him what he was thinking. Then he said, “Well I spent all night last night drawing this but I am not sure about this design. I don’t like it, so I know I have four motifs but I don’t like it yet.” Teacher 1 represented more than half of the teachers I talked to on that fifth
day. I assumed that this was because of the teachers understood the value of the *siapo* cloth, the significance of the art piece, and the permanence of each paint stroke. Finally, teachers wanted to make sure that they performed the rigid transformations correctly.

**Teacher 2 discussion on Day 5 (designing of siapo drawing).**

While talking with a second teacher on the fifth day, I asked her to share her design. This teacher had already penciled her design on her board and was ready to paint. She was eager to explain to me how she met the criteria set forth for the *siapo* assignment. When she showed me her *siapo* design I asked her to explain which motifs she slid, flipped or turned. Then she pointed to the first motif, which happened to be one of the trochus shells or *faaliao* motif, a triangular design.

![Top of the Design](image)

*Figure 4.23:* An example of a student drawing of a trochus shell claimed to be repeated by sliding.

Figure 4.23 above shows the shape that she drew which was repeated by turning or rotating the shape 90 degrees twice in reference to point A in the figure. This point also
represented the center point on her *siapo* board. I realized that she understood one way a shape or motif is repeated, which was to turn or rotate that shape, but that she was using the wrong term.

I asked her for a piece of paper and began to draw some examples for her. As I drew these figures on the piece of paper, I showed her that when a shape is slid you have to have drawn the first shape somewhere on your paper. So I asked her, “Which of these *faaliao* motifs did you draw first?” She pointed to the shape at the top of her board. Then I took a pencil and paper and drew in front of her. I said, “Ok I am going to draw my first shape or *faaliao* just like yours, on this piece of paper.” (See the triangle labeled “1” in Figure 4.27 below.) Then I said, “Ok now I am going to repeat that shape by sliding it horizontally from left to right and draw that same shape again.” (See the triangle labeled “2.”) I continued, “See the mark at the top of each triangle?” (Shown by a red dot.) “I did not turn it around. And how do I know that? When I slid it I did not change the *faaliao*’s shape, its size or its orientation.”

Then I concluded by repeating the shape a third time. Finally I reminded her that we could have slid that shape horizontally to from right to left as well.

![Figure 4.24: Example of horizontal translation that I drew for the teacher.](image)

Then I showed her two more examples of a triangle being repeated by sliding the shape diagonally and vertically. See Figure 4.25 and 4.26
The teacher then responded,

I think I get it now. Let me work on the changes and then show you later because now I think I need to find a place in my *siapo* design that has a slide (of a motif). I don’t think I have one yet. So I might have to remove some of the motifs or make them smaller so that a slide of a motif design can be made.

I left her to make corrections for a half an hour and then visited her later when she made her corrections. After checking on all the teachers’ designs I realized that, just like this teacher, a quarter of the teachers needed a few more examples to differentiate between sliding and turning.
Summer 2015

Lesson 5: Siapo 2015.

In 2015, I was again invited back to American Samoa by the University of Hawai‘i to teach the same first mathematics methods course to a new group of inservice teachers. Along with other course materials on various topics (e.g. counting, numeration, number operations) I decided to teach culturally-based lessons again. I taught the siapo lesson for a second time and chose to make it the final lesson for my dissertation. Details of each daily lesson are brief and only highlight any new additions or changes to the lesson as well as any significant discussions with the inservice teachers. A description of the teachers that were involved in those experiences follows:

Who were the teachers?

I taught this lesson to a total of 30 inservice teachers who were divided in two groups each taking the course at different times. The first group included 11 early childhood education teachers who taught children ages three and four. There were 10 females and one male. The second group included 19 inservice teachers who were all from one of the outer islands of the American Samoan archipelago, called Manua. Of the 19 teachers from the island of Manua, three
were early childhood teachers, 14 were elementary school teachers, and two were high school teachers. Five of the teachers were male and 14 were female.

All participants were inservice teachers working towards their bachelors of education degree with the University of Hawai‘i Cohort Program. All spoke and wrote in both English and Samoan and were of Samoan ethnicity. Each participant had lived more than half his or her life in Samoa or American Samoa.

**Day 1: Fieldtrip to collect dye and watch the processing of the u’a.**

My father and I planned ahead of time to add a new element to the lesson that was missing from the 2013 lesson. We discussed the *u’a* plant (the source of *siapo* bark cloth) in more detail, and extended the field trip to include observation of how the *u’a* bark was processed, and shared its cultural significance.

![Figure 4.28: My father demonstrating how to process the *u’a* tree bark.](image)

1. There were three main comments made by teachers during this field trip were:
2. Most had never seen the u’a plant before and were surprised to learn that large pieces of siapo cloth, some 50 feet in length, came from such a thin one or two inch diameter stalk. What they didn’t realize was that the small pieces of bark cloth were glued together to make the large pieces. An interesting mathematical application for future lessons would be to determine the ratio of the area of the raw bark to that of the processed bark and find out if there are any consistencies and factors determining it.

3. Most teachers were impressed to learn about the tools used by women to process the bark cloth and realized how tedious and time consuming it was. I believe this heightened their appreciation for the value of the cloth that was used during the lesson. They were careful to make the optimal use of the cloth when we cut and pasted to make the siapo.

4. They enjoyed listening to my father share his knowledge and memories of helping his mother with the siapo process when he was a young boy. Many teachers commented how important it was for him to continue to share his knowledge with others because it is a cultural practice that too few people are continuing.

**Day 2: Introducing the design elements and presentation by siapo experts.**

This day was spent introducing the 14 siapo symbols and having teachers practice drawing their siapo motifs. I was delighted to work more closely with my sister Ruta Tauiliili-Mahuka as well as a former colleague with the Department of Education in American Samoa, Atalina Coffin. They are two very experienced and knowledgeable siapo mamanu artist who shared their knowledge of siapo painting with my two groups of inservice teachers during the summer course. They helped me confirm the need to bring cultural experts and elders into the classroom to help teachers integrate cultural practices. Ruta and Atalina added two new elements to the 2015 version of the siapo lesson:
1. Ruth shared her experience of painting *siapo* symbols using an artist's perspective, and treating the *siapo* as an emotional work of art. She also asked the inservice teachers to identify symbols that had some emotional or personal connection to them. More than half of the teachers chose *siapo* symbols that had a personal or emotional connection to them. For example, some chose symbols representing the ocean environment such as the turtle net, trochus shell, and starfish.

2. Atalina demonstrated the use of red and yellow *siapo* dye colors that I had not included in the previous lesson. She was also able to bring in the actual plant roots and seed pods that Samoans used to process these two dyes. She also shared her connection to Mary Pritchard who popularized the *siapo mamanu* art form used for this lesson, as well as her cousin Tupito Walker who created and monitors the website [www.siapo.com](http://www.siapo.com), which I used as a source of research for this lesson.

*Figure 4.29:* Ruta Tauiliili-Mahuka demonstrating a motif and explaining the artist’s perspective.
Day 3: Introduce the geometrical transformations and teachers beginning their designs.

On day three I used a PowerPoint presentation to introduce the geometrical transformations of slide, turn, and flip. Will Thompson, one of the cohort coordinators in the teacher education program, helped me to animate the PowerPoint slides. I felt that this was a superior way of demonstrating the different transformations in comparison with the use of chart paper during the 2013 lesson. The technology allowed me invite teachers to participate in the demonstration by manipulating the animations and reversing them to better visualize the transformations. I also realized that this PowerPoint could be a useful resource for teachers who might want to teach this lesson in their own classrooms.

Day 4: Drawing and painting day.

On the day students drew and painted their siapo boards, there were a few significant differences from the lessons in 2013.

1. Some teachers had laptops and internet access during class and searched for more siapo samples. In 2013 there was no internet access in the room that we used to do the siapo painting. The internet access allowed some teachers to identify siapo designs, color patterns, and design combinations that they would not have incorporated had it not been for the examples they found.

2. All teachers used the yellow and red dyes (provided by Atalina Coffin) that allowed a more diverse range of siapo colors than that used by the 2013 group.

3. More teachers from the 2015 lessons asked if they could incorporate symbols, images, or names not commonly found on siapo. This raised the question of whether that would alter traditional siapo art form. I felt it was important to share with them something I had
learned from other *siapo* artists I spoke to over the years. This was to understand that in order for the art form of *siapo* to continue to grow changes to the tradition will inevitably occur. Somehow the culture has to evolve along with the way it is practiced.

**Day 5: Sharing of meaning of motifs and final siapo sharing.**

On this day teachers presented their completed *siapo* and highlighted the following: (a) their geometrical transformations as well as (b) any significance of the symbols or motifs they chose. Again the main difference between this portion of the lesson from the 2013 lesson was that students used Ruta Mahuka-Tauliliili’s suggestion to make thire *siapo* paintings a symbolic representation of themselves. However many *siapo* artists would claim that *siapo* was not meant to represent the *siapo* artist.

Here are some the examples of the symbolic representations that teachers shared: The *siapo* painting represented (a) the nature and environment where they lived because most of the *siapo* symbols represented things found in their environment, (b) cultural practices like fishing or cooking because some of the siapo symbols they used represented things found in the ocean environment, and (c) things that identified them as Samoans because the symbols were distinctly different from other Pacific island symbols used for painting bark cloth on other islands.

Finally at the end of this second attempt at using *siapo* painting as the cultural practice for this culturally-based mathematics lesson, I realized that this *siapo* lesson could be used as an exemplar to demonstrate to others how to teach culturally-based mathematics lessons. These lessons have been an important part of my learning about both my culture and the wealth of mathematics embedded within it.

Figures 4:30 and 4:31 show my last groups of teachers with their completed *siapo* paintings.
Figure 4.30: Eleven Early Childhood teachers with their completed siapo paintings.

Figure 4.31: Nineteen Manua teachers with their completed siapo paintings.
Chapter 5

What was Learned from the Culturally-based Mathematics Lessons?

This chapter will focus on what teachers learned from the culturally-based mathematics lessons, what I learned from teaching and participating in those lessons, and how my experiences with the lessons influenced my view of the field of ethnomathematics. Then I will highlight the collective impacts of the lessons on my current teaching practice. Finally, I discuss directions for further research.

What teachers learned from the culturally-based mathematics lessons.

The need for cultural sensitivity when using culturally-based lessons.

During the ratio and proportions lesson, teachers and I had a discussion about the need for cultural sensitivity when investigating mathematics in cultural practices. In particular an inservice teacher from that lesson highlighted this important idea for other teachers. When she was asked to share her ratio of coconut cream to green bananas used in her group’s dish, she said she did not know how to communicate the actual ratio. She suggested that the attempt to westernize the way Samoans measured ratios was unnatural. She said,

We (Samoans) don’t use measuring cups to measure coconut cream… I don’t know how you expect us to share our (group’s) ratio. I know we used (one bunch of) bananas and I think eight coconuts but I don’t know how many cups of pe’ep’e (coconut cream) we got from those eight coconuts, so I am confused about my ratio. (Ratio and proportions lesson, June, 2012).
She hesitated to use western mathematical terms in a cultural activity where western tools and measurements are not used. She wondered why it was a requirement to use standard customary measurements such as cups to share their group’s ratios. This idea could have been influenced by other groups reporting ratios using standard measurements in their demonstrations or my examples of ratios using standard measurements in Samoan cooking.

This teacher’s statement about her reluctance to use standard measurements was discussed with all the teachers after the ratio and proportions demonstration. Feedback from her peers during our discussion helped her conclude that what she shared, “One bunch of green bananas to eight coconuts”, was a ratio one would think about in a Samoan cultural setting. A Samoan could say, “I need eight coconuts to make enough coconut cream for one bunch of bananas”, which makes both mathematical and cultural sense. After the discussion teachers came to the consensus that there was no need to use westernized mathematical terms if it was not used during the cultural practice. I believe this was an important moment because the teachers realized the importance of cultural sensitivity and the implications of using a western mathematical lens to view the nature of mathematics in Samoan cultural practices. Furthermore, this discussion made it more apparent that there were ways in which cultural ways of thinking, language used, measurements, ratios, or estimations could be highlighted as mathematical.

_Teachers learned that it is possible for them to teach culturally-based lessons._

In the summer of 2015 I interviewed five of the 22 teachers who had been members of the 2012 and 2013 cohort groups. These teachers were selected based on their availability to meet with me during my short visit to American Samoa in 2015, and thus formed a convenient sample for this part of the study. The main question I asked was, “What did you learn from the
culturally-based lessons in 2012 and 2013?” Secondly, I asked, “Have you tried to teach culturally-based lesson in your own classroom since our course ended in 2012 or 2013?” Four out of the five teacher participants whom I interviewed said they taught at least one culturally-based lesson in their classroom since their 2012 and 2013 experiences, while one teacher stated that she did not. The following is a brief description of the four teachers’ recollections of the culturally-based lesson they taught in their classrooms, followed by the reasons given by the one teacher who rejected the idea of teaching culturally-based lessons.

The first teacher taught a *siapo* lesson in his 5th grade classroom in the fall of 2014. Evidence that this was a successful experience for both the teacher and the students was made clear described during the interview when he said:

I really liked the *siapo* lesson and I know that it’s math. When we (he and his 5th grade students) talked about lines and shapes I taught them that you (can) use any picture (*siapo* motif) and you can flip or turn it. I modeled how to draw one (*siapo* motif) design so I started with a breadfruit leaf design then I slid it along diagonally. My students said, “Ohhh!” and then they began to create their own designs. I remember that was our goal in our *siapo* lesson in your class. The *siapo* had to include those three things (flip, slide, and turn of a *siapo* motif). So my students made sure they could show slide, turn, and flip (their motifs) in their *siapo* as well. It didn’t matter to me what design they chose as long as it showed those three things. (June 19, 2015)

These comments illustrate his attempt to duplicate the *siapo* lesson to teach transformations. When asked about whether there were any differences in his approach to
teaching the lesson he said, “The only thing that was different in this lesson was I didn’t use the *siapo*. It was too expensive.”

The second teacher I interviewed taught a culturally-based lesson in his early childhood education classroom using the flat wooden rectangular *upeti* board which had *siapo* symbols carved in it. It is used for stamping *siapo*. He had his students lay plain white paper on the *upeti* template and rub crayons on the paper to highlight the designs. He then used their crayon rubbings to discuss different shapes and patterns that they saw. He explained to his young students that the *upeti* was a cultural tool used for painting bark cloth. At the end of the interview he recalled that he was very impressed with his students recalling the experience five months after the lesson was taught and how much they enjoyed that activity.

The third teacher taught a lesson to her early childhood education students on the importance of plant parts to Samoan cultural practices. She took a *launiu* (coconut frond) and coconuts into her classroom and showed students several ways Samoans used these items in cultural practices. She focused her lessons on the different uses of the coconut tree and had some students count the coconuts and leaflets during a mathematics lesson. She also used her culturally-based lesson to discuss scientific aspects of plant use.

The fourth teacher said she showed her early childhood education students how Samoans used coconuts and taro leaves to make a Samoan delicacy called *palusami*. She showed them how many coconuts it took to make five *palusami* mimicking the lesson on ratios and proportions from our 2012 course. On the last day of her culturally-based unit on Samoan cooking she had students role play how to cook Samoan food in the *umu* by bringing Samoan cooking stones into the classroom for a demonstration.
The fifth teacher was reluctant to use culturally-based lessons in her teaching for two reasons. Her first reason was, “Students should learn about the culture and language at home,” and that, “School is to help them learn English.” Her views on the current public school trends to increase the use of Samoan language in public schools in American Samoa were that this approach was going to hinder the teachers’ ability to help students master the English language. She believed that both Samoan cultural activities and language learning and teaching should be left to the parents to deal.

Secondly when asked whether culturally-based lessons would have a place in our school curriculum she stated, “If it is hard for me the teacher then it will be hard for the students.” She was referring to her level of understanding of the Samoan cultural practices involved in the four lessons taught in 2012 and 2013 and realized that if she did not know the cultural practices she was not going to attempt to teach a culturally-based lessons in her classroom.

Four out of five teachers used culturally-based lessons as a strategy to teach younger children the importance of various topics including mathematics, cultural practices and science. Only two out of the four used it to teach mathematics concepts directly. These teachers suggested that they plan to continue to use culturally-based lessons as a way to integrate mathematics or science concepts that they are required to teach. The last teacher represents those teachers who feel that there should be a separation between current school academics and the Samoan culture and language. This group of teachers believe that if teachers are not equipped with the cultural knowledge they should not be teaching it.
Teachers learned mathematics themselves by using culturally-based lessons.

During each of the culturally-based lessons several teachers commented on the uniqueness of the strategy to use cultural practices to learn mathematics and emphasized the mathematics they were learning during the cultural lessons. Below I offer several quotes from teachers based on the lessons that offer their thoughts about this strategy.

Salulima lesson 2012

“This is a simple task but you can teach a lot of math from it.”

“I always use a salulima but I didn’t know you can use it to teach math. This is will be fun.”

“I am going to use this to teach counting by twos, threes and fours.”

Ato launiu lesson 2012

“Patterns in the ato are confusing but I know this helps me think about math. It’s just like number and shape patterns.”

“I am really good at patterns but this is hard. I think I need to take notes on the patterns that I learned. I really need to study this more. This is a good way to learn math.”

Ratio and proportion lesson 2012

“I cook every day for my family and didn’t realize that I am doing math... how many times did I do math today? Wow so many times!”

“I think if I learned math this way I would have really liked it more. I think I am starting to like it.”
Siapo lesson 2013 and 2015

“I have never made a siapo before, but now I see a lot of math in it.”

“I didn’t know Samoan art can be math too.”

“Now I know Samoans used a lot of math…I like this kind of math. Siapo was just plain sense to me but now I see it differently.”

These comments highlighted the significance of using culturally-based mathematics to teach mathematics that was both interesting and novel but also a way to raise teachers’ awareness of the availability of mathematics in everyday activities. Teachers were learning and in some cases re-learning mathematics as they were experiencing or teaching these lessons.

What I learned from participating in, and teaching, the culturally-based mathematics lessons.

Use of inquiry questions to guide lessons.

During the salulima lesson I realized that my use of inquiry questions to guide and extend the problem solving aspect of the lesson was a good teaching strategy. Part of this stemmed from my interest and admiration for the teachers’ enthusiasm and motivation to discuss and share their own experiences about the decision process in completing an authentic cultural task. I realized there were more mathematics concepts I could teach from this cultural practice than just counting the tuaniu (midribs of the coconut leaflet). This was a direct result of using questions to help teachers further investigate the cultural practice. The evidence of the value of this strategy came from the higher levels of teachers’ engagement with the lesson tasks, teachers’ excitement and comments after the lesson, “Learning math this way is so much fun,” and, finally, in the increased meaningful discussions among the teachers themselves.
The importance of questioning also had a tremendous impact on my teaching in southern Utah as a STEM teacher. I now use guided inquiry questions for all of the science lessons that I teach in STEM courses for elementary students. One example of this is the set of inquiry questions I generated for a unit on heat and light in the third grade. Each of the lessons began with an inquiry question that we discussed before any investigation took place. Here are samples of the questions I used: (a) What is the difference between hot and cold? (b) How do I make things hot? (c) How do I make things cold? and (d) What are things that affect how hot or cold something is? These inquiry questions have also had the same effect as the questions in my culturally-based lessons. They have led to deeper and more thoughtful discussion. They have generated an enthusiasm among students to share their own experiences. Students have exhibited an increase in their motivation to learn, and excitement for science and mathematics.

*Power of doing mathematics.*

I remembered selecting *siapo* painting as a cultural practice that was embedded with mathematical concepts because of the symmetry and transformations used in their designs. This was also the main reason why it was selected for my first research project in culturally-based mathematics lessons for Project MACIMISE. I remembered comparing my initial thoughts about the mathematics involved with the *siapo* painting, prior to any experience making a *siapo*, with the mathematics concepts I learned after making my first *siapo*. I realized that reasoning and logical thinking were intensified and more sensible when actions were coupled with mathematical thinking.

An example of this hands-on learning occurred when I drew lines and created my shapes for my first *siapo* painting. I tried to repeat the shapes I was drawing by sliding, flipping, and
rotating these shapes to complete a traditional *siapo mamanu*. As I drew shapes I realized a correlation between shape size and number of times it could be repeated. The larger the size the fewer times it could be repeated on the siapo board. Because of this limitation there was purpose in estimating the extent of the area in which a shape was to be repeated and purpose in selecting a size that would allow a determined number of repeated shapes. This was an important skill in making sure that shapes fit nicely in a space and added to the aesthetic beauty of the *siapo* painting. This was one of many examples of how I came to realize various mathematical ideas while performing a mathematical task. This conceptual understanding of the relationship between the size of the motifs and the number of motifs on a *siapo* was not something I would have realized had I not created one myself. This was a powerful moment in my teaching and learning career relating the act of problem-solving using hands-on materials to the construction of mathematical concepts or schema.

**Difficulty with patterns.**

The *ato launiu* lesson taught me that teachers should understand pattern recognition is a skill that can be developed, and they need to understand that it poses difficulties for students and their learning of mathematics.

The braiding of the bottom portion of the *ato launiu* was always a difficult pattern for me to remember and therefore explain. I remember when I was 12 years old, I always forgot how to begin the braid my father had taught me. This difficulty was compounded if I ever started the braid correctly but lost track of the pattern midway through the braid. From the mid-point on in the braid, I always remembered asking someone else to finish my *ato launiu* braiding.
Because of this difficulty in the recognition and retention of the *ato launiu* braiding pattern, I realized how pattern recognition may be difficult for some people. It helped me empathize with students who struggle to see patterns that others find very easy. I thought that was an important thing for me to realize not only as a learner of mathematics and cultural practices but more importantly as a teacher. I was made aware at that point in time that it is imperative to be empathetic to students who struggle with new concepts or pattern recognition. I saw this phenomena many times when I taught students steps to solving problems with fractions or algorithms or even steps to weaving or braiding an *ato launiu*.

As I focus on my current role as an elementary teacher I continue to reflect on the lessons learned about importance of learning patterns as well as the inherent difficulties children face in doing so.

*STEM connections.*

*Salulima lesson:*

After teaching the *salulima* lesson I remembered thinking teachers were making science connections to plant characteristics of the different *tuaniu* (midribs) such as differences in *tuaniu* length, thickness, and rigidity. No one explicitly mentioned that they were making scientific observations but when asked why the *tuaniu* were different, certain teachers related the variance in the *tuaniu* characteristics to the varieties of coconut trees. Different coconut trees had different types of *launiu* (coconut fronds). Some *launiu* had thicker *tuaniu*, useful for a sturdy broom, while other *launiu* had thinner *tuaniu*, unsuitable for a sweeping tool. They also said that differences in thicker and thinner *tuaniu* could also be related to the maturity of the *launiu*. The mature *launiu* had thicker and more rigid *tuaniu* as compared to the younger less mature *launiu*. 
This then led to a discussion about Samoan cultural knowledge about the varieties of plants on the islands such as varieties of breadfruit and banana plants and their fruits. After poring over my notes, I realized that the discussion of coconut varieties correlated nicely with the dialogue among teachers about their knowledge of other cultural plants.

My father taught me a lot about the different varieties of breadfruit and bananas when I was younger. During the group discussion that night, someone mentioned that there were different varieties of coconut trees and some the characteristics of their launiu varied. I shared my cultural knowledge and ask teachers to describe as many different varieties of coconut, breadfruit and banana trees as they were able. Only a handful of teachers were able to name common varieties of coconut, breadfruit or banana found in American Samoa. I thought that sharing my excitement at being knowledgeable about different varieties of traditional plants might lead to teachers in turn realizing that it was important to observe nature and the environment.

_Ato launiu lesson:_

The _ato launiu_ lesson helped me make additional connections between decisions Samoans made concerning the weaving and braiding of the _ato launiu_ that are directly related to science, technology, engineering and mathematics ideas. For example:

1. the length of the _launiu_ (coconut frond) used to weave the _ato launiu_ determined the basket’s circumference and diameter;
2. the type of braid, the length of the _tuaniu_ (coconut leaflets), and the basket’s circumference and diameter affected the volume of the _ato launiu_;
3. the patterns of both the woven and braided portions of the basket were distinct, and directly impacted the basket’s size and strength; and

4. the pattern of the weave could be related to odd and even numbers and alternating types of patterns.

The idea that one cultural activity or lesson can have many scientific, technological, engineering, and mathematical connections is promising because of our nation’s new focus on Science, Technology, Engineering, and Mathematics (STEM) education as well as my own personal interest for further research in this area. Culturally-based lessons can be used to help Pacific island communities in Micronesia and Polynesia, where most of my Project MACIMISE colleagues work and teach, become pioneers in bridging the gaps of culture and global trends in mathematics and science education.

**Differences in teachers’ responses to lessons.**

There were notable differences in teachers’ responses to the lessons. One of the differences I noticed among teachers was that when they were asked about the cultural practices themselves. Some of the older teachers recalled cultural practices with more detail. They were also able to identify more of the cultural tools and use more terminology involved in a cultural practice than the younger teachers. This is evidence that the newer generations are witnessing and performing these cultural practices less frequently. These phenomena were evident in each group of teachers I taught in 2012, 2013, and 2015.

Another difference I noticed was that in depth cultural knowledge between teachers who were from rural villages or islands as compared to those teachers who were from urbanized
areas. The teachers from rural areas had a lot more knowledge of the cultural practices than their counterparts. This is mainly because people living in rural areas are continuing to practice more traditional life styles.

_Importance of elders._

The support, knowledge and skill of the elders with whom I consulted, allowed me to better plan and more effectively implement the culturally-based mathematics lessons described in this study. Elders helped teach me the cultural practices and traditional language associated with each cultural practice. On those occasions when elders participated and effectively co-taught the lessons, teachers showed heightened interest in the activities. The knowledge and skills of elders played an integral role in maintaining the cultural accuracy, relevance, and authenticity of the culturally-based mathematics lessons.

I learned that elders may play a key role in culturally-based lessons. In those schools that support the presence of elders and their integration into the education of children, teachers are encouraged to develop and implement culturally-based mathematics lessons. Teachers shared that they have seen elders invited to help present and share local knowledge on the school campuses. They also shared that this is important mostly in areas where teachers lack the background to teach the cultural practices themselves as it was in my case. This connection with elders in their capacity as teachers of the cultural practice also helped me understand the importance of the cultural ways in which they teach. The way in which they teach imparts cultural values and traditions as well as an emphasis on correct use of language. The elders also have a great understanding of the history of the culture and any recent changes in practices. This helped me bridge the gap between customary cultural practices with those that have evolved or are slowly disappearing because of foreign influences and globalization.
What we learned together from the culturally-based mathematics lessons.

Connections between mathematics and culture.

Salulima lesson.

During the salulima lesson, discussion about connecting mathematics and the Samoan culture took place while inservice teachers actually constructed the salulima. This directly parallels D’Ambrosio’s (1997) description of ethnomathematics as a field of mathematics that is focused on connecting one's cultural practices and the mathematical knowledge and methods used to accomplish that practice. During the cultural practice teachers identified decisions that influenced the making of the salulima and made mathematical connections among those decisions. For example, one of the four groups discussed how the girth of the salulima handle correlated to the circumference of a person’s grip. One of the teachers then began to show how they might grip the handle. In turn she said, “If you look at my grip, it forms a circle and this could be the same as a circumference.”

Teachers in a second group realized that in this traditional practice the maker identifies the girth of the salulima handle by gripping the handle after gathering the number of tuaniu (midribs) needed. This also led to a discussion in the third group about possibly making a wide range of salulima with handles of different girths—adding tuaniu to increase the size of a handle for a salulima used by a mother, or subtracting tuaniu to decrease the size of a handle for a salulima used by a young child. Teachers could not confirm whether the making of different-sized salulima handles to fit the grips of various family members was a common cultural practice. However, most teachers agreed that the number of tuaniu used was dictated by the size of the salulima handle, as determined by the size of the maker’s hand-grip or the hand-grip of the
salulima user. At the end of the salulima lesson the teachers and I had an extensive discussion about the importance of bridging the gap between mathematics and cultural practices, and helping others become aware of those connections. One teacher’s comment highlighted their collective statements about connections between mathematics and culture,

I wonder how many Samoans realize that they are doing mathematics when they are doing daily chores, such as cooking, or making a salulima? I wish we could use these kind of lessons in school. I think my students would really like this. I know we can help teach our children about the (Samoan) culture too (June 12, 2012).

*Ratio and proportions lesson.*

During the ratio and proportions lesson demonstrations most of the teachers said they learned new Samoan culinary recipes, which expanded their understanding of ratios as relationships among quantities. They also discovered new ratios such as, the ratio of the number of coconuts to the number of cups of coconut juice obtained was approximately one as to two. Most of the teachers shared that this lesson helped them realize that Samoans practiced mathematics and were quite good at estimating, measuring, and problem solving. Finally most of the teachers stated that they wished they had thought to relate mathematics to cultural practices. This might have helped them become more successful in understanding academic mathematics learned in school, as well as the application of academic mathematics in real life situations.

This ratio and proportions lesson also helped me reflect on how my uncles and aunts, with whom I learned to cook traditional food, learned through their own experiences how many coconuts were needed to make enough pe’epe’e (coconut cream) for a given pot of cooked starch (taro, breadfruit, or bananas). I learned to appreciate my older family members for helping me
realize that many Samoan elders exhibit mathematical skills and knowledge learned from their personal experiences, as represented in how they perform certain cultural practices really well. When I talked with my Aunty Sina in 2012 about my work with teachers on the ratios and proportion lesson, she was a little surprised at how much credit I gave her for her knowledge of mathematics. I explained to her the link between her cultural practice of making pe’epē’e (coconut cream) and mathematics, helping her think of her actions differently, if only for a moment. We began to talk about how she measured ratios in her cooking and what she used to describe those relationships. As she talked more about her culinary ratios, I stopped her and said, “That is mathematics, when you are cooking and making ratios of bananas to coconuts, that is mathematics.” She seemed surprised, underscoring to me that Aunty Sina didn’t feel that her knowledge was mathematical at all. Perhaps she thought that mathematics and culture were always two separate ideas and that it was not often that people connect the two. Or maybe Aunty Sina thought only of mathematics in western mathematical terms, like cups or inches, or terms learned in a school setting. Either way, Aunty Sina’s reaction exemplifies how thinking of mathematics only in western mathematical terms limits culturally significant non-standardized measurements, such as hand spans or hand scoops, as not mathematical measurements.

Handling misconceptions of mathematical language.

In the siapo lesson I had introduced the concept of geometric transformations. As I taught the concept I realized that teachers were confusing two terms, slide and turn. Approximately one quarter of the teachers in both lessons confused a slide for a turn. The same teachers who were confusing these during the creation of the siapo were also those confusing the terms when they
were asked to identify these transformations at the end of the lesson. I offer a few hypotheses for this confusion.

My first hypothesis for the difficulty stems from the teachers’ understanding of the term “slide.” Perhaps it stems from our collective connotations of everyday language in mathematical applications. For example, when I think of things that slide, such as cars on slippery roads or people on banana peels, we experience that cars or people may also twist and turn or even flip over as a result of that slide, but we don’t often say he “slid and flipped and turned,” we just say “the car slid,” or “the person slid.” So often times we use the word “slid” or “slide” to explain what happened but tend to also envision other movements to match the experience we think of when we say the word “slide.” Furthermore, when consider mathematical terms that have more than one meaning, such as the term “divide,” which means either equal sharing or grouping, we often have a dilemma if our everyday connotations for the word “divide” are in conflict with the mathematical connotation of the word.

For example, in Samoan customs when we divide a pig or catch of fish for families or elders it is seldom divided equally. In fact, in cultural ceremonies rarely is anything divided equally because portion sizes are dependent on is receiving the portion. A person’s cultural status correlates with the size of the portion they receive. However, in mathematics when we discuss use the word “divide” we expect that each portion is of equal value. This then could be the cause of problems with word usage as is it stems from confusing their experience or connotation of the term with mathematical applications of the term.

A second hypothesis for the confusion is that it arose because of deficiencies in my modeling or explanation, and choice of examples. I may not have provided sufficient examples or non-examples of a slide or turn to help teachers construct an accurate understanding.
of the term. When the geometrical examples were given, I felt that I could have done a better job checking for understanding by asking teachers to demonstrate these movements. I could have guided teachers to think of a slide in terms of linear movement without turning or flipping the shape or motif on the *siapo*.

**How my Experience with Culturally-based Mathematics Lessons Changed my View of Ethnomathematics**

**Use of nonstandard measurements.**

During the ratio and proportions lesson the idea of nonstandard measurement came up during several of the demonstrations. Teachers commented on how the coconuts, bananas, *launiu*, and handfuls of flowers were not all the same size. They wondered how we were to deal with this when they reported their ratios and found it posed difficulties in accuracy of the mathematics.

The use of nonstandard measurement techniques and items made me think of all the nonstandard measurements Samoans use in cultural practices. There are several distinct nonstandard measurements using both hands and feet used to measure either capacity or linear measurements in construction or weaving mats. Those will not be discussed in detail here. I noted that the use of nonstandard measures became a thematic occurrence throughout the cultural lessons. My intention was for teachers to realize the importance of helping students understand that many units of measurement initially grew from parts of our bodies. This realization needs to be honored and discussed with students. However, during the time that the culturally-based lessons were taught, I did not realize that understanding nonstandard measurements was so important. I would like the opportunity to go back, and say, “Look at how valuable nonstandard
measurements are to people and how much we need to know and understand that there is value in understanding that we use them all the time.”

**Importance of trial and error in ethnomathematics.**

Trial and error form an important basis of ethnomathematics. One day, I learned from one of our advisory committee members in Project MACIMISE, Jerry Lipka, something that applies to this claim. We spoke for some time at a meeting in Palau in the summer of 2012 about how people know or understand mathematics and how they come to realize the mathematics we use today. He used the example of cooking rice, a cultural practice, and asked how I cooked rice. I told him that I use a technique that I learned from my aunt that had me use the tip of my finger to measure how much water I needed, a technique that I have observed is very common amongst many rice-eating people in the Pacific region. I am not sure about other places.

Then he asked,

How does one know how much water he or she needs to cook rice if he has never made rice before or mastered the skill yet? Well I suspect that when people try to figure things out they just try it. And in the example of making rice they will find out the result of their efforts. If it’s too watery then they adjust their amount of water somehow, and if it’s not cooked and needs more water than they adjust. It is in the adjusting process that they come to figure out the suitable ratio and proportions of water to uncooked rice that make a suitable pot of rice (Jerry Lipka, personal communication, Palau, 2012).

This conversation with Jerry Lipka made me think about mathematics in applications to real life. I love to apply mathematics to cooking because it is so universal. Another realization
was to think about mathematics was in terms of simple things, things that we tend to ignore or not especially notice. I think it’s this heightened sense of awareness of things that we do and the process of thinking about it consciously instead of subconsciously that helped me understand mathematics in a new way. I realized that mathematics didn’t just exist in schools and in textbooks. It involved real people making real decisions and choices. And it is in these adjustments after many trials and errors that we develop skills to solve problems. Then as we solve problems and come up with generalizations about rules that govern those situations we come up with theories about problems that arise in those situations.

I think that trial and error explain how elders have developed important cultural practices. The actions that lead to carving a canoe, building a house, making Samoan food, and weaving a basket have developed into highly complex skills. All these cultural practices are related to mathematics through ethnomathematics. Trial and error are a significant factor in perfecting such skills.

**Importance of authentic cultural experiences.**

The lesson on *siapo* painting became the most intense and time-consuming culturally-based mathematics lesson I taught. It was also the most expensive because we had to buy large quantity of bark cloth that was hard to find on the island of Tutuila. I often worried that I had dedicated too much of the course time to maintaining the authenticity of the cultural activity. I reflected on that decision many nights during our *siapo* making. One of the things I noticed right away was that the time spent discussing the *siapo* art making, processing of dyes, and the discussions about the cultural and historical significance of *siapo* outweighed the time spent talking about the geometrical concepts that I had hoped to teach from this cultural activity. I
realized later, in the way that teachers proudly spoke about the experiences, that the cultural authenticity of the lesson was a large part of the process of developing mathematical awareness and discussion that would allow teachers to bring meaning to this lesson. I don’t believe we would have had such rich dialogue about the link between mathematics and culture had I not used authentic *siapo* cloth and dyes.

The authenticity of the project and its materials however, would make this a hard lesson to duplicate in a classroom setting. I wondered how teachers would teach this lesson if they did not have the actual *siapo* bark cloth. I share one of the responses of a teacher participant from the 2013 *siapo* lesson. This interview took place in the summer of 2015. When asked about the use of authentic materials during his culturally-based mathematics lesson on *siapo* with his fifth grade class in 2014, he said,

No (we didn’t use the actual *siapo* cloth or dyes) we could have, but the materials for the *siapo* are expensive and hard to get, so I chose to do mine with paper and pencil. Yeah it’s too expensive and hard to find. Remember we had a hard time finding material for our class (*siapo* lesson in 2013). Remember that?

This teacher’s comments also helped me to realize that one of the struggles that would limit the future recognition of the effectiveness of ethnomathematics would be the extent to which authenticity is reduced because of the nature of the costs associated with implementing cultural practices.

The authenticity of the lesson was also a topic for discussion with cultural experts or elders, university faculty, former teachers as well as the teachers involved with the *siapo* lesson. I have received feedback that falls into three main categories: These categories are represented by these paraphrased statements concerning the need for authenticity in culturally-based lessons.
1. Cultural experts have said that there is a need for more culturally-based lessons that help preserve the knowledge and skill that will soon be lost. Because authentic tools and materials are used in these lessons, experts expect that teachers will value their roles in teaching young students cultural practices that might otherwise be forgotten.

2. University staff and former teachers have said that there is a great need for the type of integration that is coupled with authentic learning experiences. Authentic culturally-based lessons can become a way for teachers to learn how to teach place-based learning lessons as well as lessons focused on integration.

3. Teachers involved in the siapo lesson thoroughly expressed their gratitude for the authenticity of this lesson, because the siapo making “was their first time.” This was echoed by all of the teachers involved in the siapo lesson.

**Ethnomathematics as part of today’s curriculum.**

I believe that ethnomathematics should be an important and vital part of mathematics taught in our local schools. An ethnomathematics supplement to a mathematics curriculum would allow students to build mathematical understanding in contexts that they are familiar with or at least contexts that have some significance to their immediate environment. Cultural practices could be used to help students develop and generate useful mathematics that helps students make important connections to mathematics taught in school. I believe that mathematics taught without context is linked to students' anxiety, apathy, and negative feelings toward schooling. I also maintain that a context-rich ethnomathematics approach will provide a way to address these concerns. When ethnomathematics lessons match teachers and students with multiple cultural commonalities there is potential for a positive dynamic to occur. This is especially true if the cultural practice is relevant to the lives of both student and teacher. When
both perform the cultural practice and explore the mathematics involved in it, teachers and students can both appreciate that practical and formal mathematics are learned in a real context.

My Teaching Transformation

The growth of my pedagogy.

Table 5.1

Growth of Teaching Pedagogy

<table>
<thead>
<tr>
<th>My Teaching Experience</th>
<th>My Predominant Pedagogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997-2000</td>
<td>Direct instruction, Facts and testing, Expert knowledge</td>
</tr>
<tr>
<td>Teaching Algebra, General Mathematics, Geometry, and Algebra II</td>
<td></td>
</tr>
<tr>
<td>2000-2003</td>
<td>Direct instruction, Facts and testing, Expert knowledge</td>
</tr>
<tr>
<td>Teaching Prealgebra, and General Mathematics 7th grade</td>
<td>Began to experiment with group work, Choice Desks in groups</td>
</tr>
<tr>
<td>2006-2010</td>
<td>Limited direct instruction, Group work, Discovery learning, Experience</td>
</tr>
<tr>
<td>Teaching Mathematics mathematics courses for the University of Hawaii</td>
<td></td>
</tr>
<tr>
<td>2012-2015</td>
<td>Limited Direct Instruction, Discovery Learning Group work, Self-reflection, Self-directed tasks</td>
</tr>
<tr>
<td>Teaching summer courses Math 111 for University of Hawaii</td>
<td></td>
</tr>
<tr>
<td>Teaching STEM in Southern Utah</td>
<td></td>
</tr>
</tbody>
</table>

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Table 5.1 shows some of my own personal changes and growth from a traditional teacher to a more student-centered teacher. These pedagogical transformations took several years of experiences, observations, personal reflections, extensive research, personal experiments, and finally an in depth perception on the best methods of teaching for the benefit of the learner.

Who am I now?

For the past three years, I have been teaching elementary children in southern Utah. I was hired in 2012 as a STEM (Science, Technology, Engineering, and Mathematics) teacher to assist the elementary school in piloting STEM integration which also focused on teaching the science core standards required for each grade level. One of the ways that was accomplished was to have a designated teacher, myself, that focused on assisting the already great staff at teaching more science to each student each week. My main objective was to revisit the Utah state core science standards that all students were supposed to learn and work collaboratively with teachers to design and implement lessons that allowed me to extend science topics teachers were already teaching. I had just completed my third year towards the end of the doctoral dissertation research study and have completely and utterly enjoyed the experience to teach and work with such a wonderful staff and administration and equally great community of parents and children.

However, the beginning of my journey as a full time STEM teacher in the mainland United States was not met without huge fears. The challenges to adapt, learn, and navigate a new curriculum, a new school system, and a foreign culture and norms were my biggest fears. For that reason I spent a lot of time making observations of teachers and students to make sense of my new surroundings. My generalizations and rationalizing led me to compare every new
situation, and I had presumed that things would be tremendously different and difficult for me to get used to. However I realized that much of what I understood about the epistemology of the culture and norms of an elementary school were more similar between American Samoa and Utah than I expected. Coupled with my nature of seeing the brighter side of things and working with such a welcoming and supportive administration and staff I realized that I would quickly adapt and become comfortable with my surroundings.

Many of the ethnomathematical experiences during my involvement with Project MACIMISE were also influential in my success as a STEM teacher. Ideas such as constructivism, hands on learning, discovery learning, as well as real life application that were a huge part of my evolution in understanding how students learn were great assets in helping me create learning experiences that helped students learn content in a motivational way. I continue to owe a lot of my success as a STEM teacher to the experiences linked to Project MACIMISE.

Suggestions for future research

The need to recapture our past

One of the duties I owe my children and young American Samoans is to help them learn about their history, culture, and language. I must help them understand the rich mathematical and scientific knowledge our ancestors possessed to solve problems in their natural world. My shared fears with Samoan elders I have spoken with, is that much cultural knowledge and many skills will soon be lost forever. More importantly we hope that the younger generation is receptive to learn about their culture and language.

My experience with culturally-based mathematics lessons and especially the research needed to help me produce and teach these lessons left an indelible mark on my views of my
responsibility to pass on that cultural knowledge to others. Many of the cultural practices that I shared with the teachers were directly passed on to me by elders. Since I began with Project MACIMISE, cultural knowledge, traditional language, reasons behind cultural activities, and tools used for cultural practices have been major topics of conversation between me and my father. This has led me to a very personal connection to recapturing the knowledge of elders, one of the three major goals of the Project MACIMISE.

My father and I would spend nights talking about how he witnessed and participated in many cultural activities as a young boy. This was mostly because he was born and raised in a village where these cultural practices were a part of everyday life. He takes pride in knowing and understanding the value of passing on the language, context, and values of these cultural practices to his children and in turn hopes that we do likewise.

Development of Ethno-STEM studies

One topic for future research in ethnomathematics is its correlation with the areas of ethno-science or ethno-STEM (Science Technology, Engineering, and Mathematics), which is a hot topic in education and relates to my work as a STEM teacher in southern Utah. I am focused on the role of integrating mathematics and science, engineering and technology and I see the possibilities of taking my four lessons and using them to teach STEM in American Samoa. This could open up several possibilities for research in ethno-STEM. More culturally-based lessons could be developed analyzed with a STEM lens which might further develop our understanding of the knowledge and skill our ancestors and elders possess. Ethnomathematic’s research can then be a likely partner or avenue of the bigger picture.
The need for bridging the gap between elders and school communities

There needs to be a way to increase the role of elders in school communities. How this can be successfully achieved needs to be an area of further research. With teachers and students growing use of social media it is my hope that educators and those interested in ethnomathematics in the Pacific and in American Samoa can help capture video of these elders performing the cultural practices and share these on a social platform. This idea stems from my fear that the students and teachers would could benefit from the elders understanding and wisdom of cultural practices far outnumber the elders who possess it.

Furthermore, ethnomathematics and part of its emphasis on bridging the gap between western mathematics and cultural knowledge may help our younger children learn how to relate to both. Western ideas and terms cannot be avoided in our Pacific island homes and schools. The influence of modern education and standardized tests have an impact on what teachers can teach as well as what students end up learning. At the same time, however, culturally-based mathematics lessons, like the salulima and ato launiu lessons, can help teachers and students understand new layers of our culture and in turn use our culture to help understand mathematics. Therefore, one of the goals for future ethnomathematics projects or research should be to help cultural experts become aware that mathematics is something they do every day to solve daily problems and that their knowledge is worth sharing.
References


