PARTICIPANTS' JOURNEYS IN PROJECT MACIMISE (MATHEMATICS AND CULTURE IN MICRONESIA: INTEGRATING SOCIETAL EXPERIENCES)

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ABSTRACT

Project MACIMISE (Mathematics and Culture In Micronesia: Integrating Societal Experiences) began in 2010. The first project of its kind ever attempted, its aims were threefold: First to examine local cultural practices and work with elders or other experts to rediscover and/or uncover indigenous mathematics in each of ten participating Pacific islands and island groups (Hawai‘i, Pohnpei, the Republic of the Marshall Islands, American Samoa, Kosrae, Chuuk, Guam, Saipan, Yap and Palau); second to use knowledge gained from this to design, implement and assess mathematics curricular units for grades one, four and seven; and third to build local capacity by offering advanced degree opportunities to participants. Twenty-two people, myself included, participated in Project MACIMISE, which is scheduled to end in 2014. This study explores and documents the journeys of eighteen MACIMISE participants using data collected between January 2010 and December 2013 in an attempt answer four questions: First, what happens when participants in Project MACIMISE study traditional and local practices to uncover indigenous mathematical ways of knowing; second what happens when they attempt to create and implement mathematics curricula based on these practices; third what are the similarities and differences when the participants share about their experiences; and fourth how can we use these discoveries to inform future projects similar to MACIMISE?

This study tracks the difficulties, challenges, struggles and successes of the participants. Using a variety of qualitative research methodologies, participants describe the ways in which the project met or failed to meet their expectations; they describe new

understandings about how their island cultures mathematized their world; they describe a sense of urgency about documenting what is left of their cultures' indigenous knowledge before it disappears; and they discuss the conflicts and violations they negotiated while trying to embed indigenous mathematical knowledge and practices within primarily Western-modeled educational settings. The study also explores the concept of ethnomathematics and how the project applied or failed to apply ethnomathematics. By being a participant-observer in Project MACIMISE, I reach conclusions about the nature and utility of ethnomathematics.

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PART I

THE STUDY: CONTEXT AND METHODOLOGY

CHAPTER 1

INTRODUCTION

In this chapter I provide necessary background and context about a project called Mathematics and Culture in Micronesia: Integrating Societal Experiences (MACIMISE). I then explain my rationale concerning the format of this dissertation, which for several reasons departs from conventional forms.

Project MACIMISE

MACIMISE is a collaborative project led by Pacific Resources for Education and Learning (PREL), supported by University of Hawai‘i at Mānoa (UHM) and funded by the National Science Foundation (NSF). One of the primary goals of MACIMISE was to equip Pacific island teachers with the knowledge and skills to apply ethnomathematics in their classrooms, with the overall aim of improving student achievement in mathematics. The inspiration for the project occurred almost by accident. In 2000, the principal investigator for MACIMISE, Dr. A.J. “Sandy” Dawson was in Yap for the final phase of an NSF-funded education project called MENTOR. Over a meal with one of the participants, who was a Yapese native, the question arose: What future projects might be done if funding could be acquired?

> This was his thoughtful and heartfelt reply: “For eight years we’ve studied Western mathematics, mainland [United States] mathematics and teaching approaches that are suited to mainland children. Why don’t we ever look at Yapese cultural practices and languages, examine them for the embedded mathematical knowledge and then create lessons and units of work for our

> children that are based on things they've experienced? Not many Micronesian children have ever experienced snow, but they sure know about fishing in the vast Pacific Ocean." (Dawson, 2013, p. 45)

Thus began the MACIMISE journey, which extended well beyond Yap to include MACIMISErs from other island groups across the Pacific: Palau, Guam, Saipan, Chuuk, Pohnpei, Kosrae, the Republic of the Marshall Islands, American Samoa and Hawai'i.

The twenty-two MACIMISE participants began taking the courses required for their doctoral and masters degree programs in 2010. UHM and University of Guam (UOG) faculty taught synchronized on-line courses in spring, summer and fall semesters using the Blackboard Collaborate platform to bring together people from such disparate island groups (and time zones). In addition to the online coursework, the entire group met each summer, along with UHM, UOG faculty and various consultants from universities across the U.S., in one of the participating island groups—Saipan in 2010, Pohnpei in 2011, Palau in 2012 and in Hawai'i in 2013—to hold classes, attend and present at conferences and experience the culture of the host island.

Project MACIMISE had three primary objectives: First, participants were to examine local cultural practices and work with elders or other experts in their communities to rediscover and/or uncover indigenous mathematics. Second, participants were to develop, implement, assess and refine mathematics curriculum units for grades one, four and seven based on these cultural practices. Third, the project aimed to build local capacity by offering advanced degree opportunities for educators who would

otherwise not have access to quality postgraduate programs in their far-flung island groups.

At the time of this writing, spring 2014, MACIMISE is in the last of its five scheduled years. Most of the participants have examined local practices and designed their mathematics units. More than half have piloted and assessed the first iterations of their curriculum units. Twelve participants have reached the third goal; they graduated from UHM with masters degrees in May 2013. The others, including me, have finished their coursework towards their doctoral degrees and are in various stages of writing or defending their dissertations. Two have successfully defended as of the end of December 2013.

The Format of this Dissertation

Dissertations typically follow a standard format; there are five chapters. The first chapter introduces the study; the second reviews the relevant literature; the third describes the research design and methodology; the fourth presents data analysis and findings; and the last offers a discussion, conclusions and implications for further research. However, this dissertation departs from the conventional format.

Those of us in the MACIMISE program have been on a difficult journey in pursuit of something that's never been attempted before: recapturing—and honoring—the indigenous mathematics that evolved in different island groups spread across 1.5 million square miles of the Pacific. Given the degree to which Pacific islands have historically been colonized and assimilated, this alone was a major challenge. We then attempted to connect whatever indigenous knowledge we could uncover to curricula in local schools,

where content and pedagogy almost exclusively follow Western mathematics education models. The difficulties we've experienced derive from the fact that these aims—to develop mathematics curricula relevant to and appropriate for the children of the Pacific, to implement the curricula in schools that most often require teaching mathematics designed around mainland United States mathematics standards and then to use these curricula to foster greater achievement in mathematics—are often at odds with each another. My research attempts to elucidate the process by which MACIMISE participants both successfully and unsuccessfully navigated and negotiated these difficulties.

In one of our first meetings in 2010, Dawson told the group that we were "creating a path laid by walking." One of the consultants further related that the NSF had described the MACIMISE project as "exploratory" and "high-risk." That the participants represented so many disparate Pacific cultures spread over such a vast region meant that there was a great variety of experience within the general structure of the program. Unlike well-established and tested training programs, the path of MACIMISE was neither linear nor even teleological. In my experience the MACIMISE journey was organic, dynamic, with the participants' paths sometimes tracking parallel, sometimes diverging and sometimes intertwining to form new and unexpected paths. I have therefore chosen to format my dissertation in a fashion that reflects and re-enacts this fairly unpredictable generative process. As Shawn Wilson described in *Research is Ceremony: Indigenous Research Methods* (2008), the presentation of my research "does not follow a linear process…but rather a more cyclical pattern that introduces themes, then returns to them at intervals with different levels of understanding" (p.42).

One of my paths was to find a definition that encapsulated this research. I detail this process in chapter two, in lieu of the standard presentation of relevant literature. In that chapter I identify my personal lenses and whatever dominant—and, in this case, indigenous—paradigms have guided my research process, and I discuss the ways in which my identity and my dual roles as both researcher and subject have intersected. The third chapter chronicles my struggles in approaching the study and why my research questions and methods changed as MACIMISE unfolded. In a conventional dissertation, the content of all of these chapters would be presented as findings in the fourth chapter. Instead I thread my findings throughout the dissertation, in all chapters, with relevant literature cited where appropriate. In my view, this approach exemplifies the "more cyclical pattern" described by Wilson.

As if participating in a project the likes of which had never been done and walking an uncertain path from its outset weren't challenge enough to Western modes, all of the participants are Pacific Islanders. Most people who live in or are familiar with Pacific island cultures would likely agree that Pacific Islanders have unique ways of thinking about, perceiving and interacting with the world, and in particular with their local environments. I needed to account for that uniqueness, explainable partly by the histories and social realities of the various islands we call home as well as by the personal circumstances we each individually face. The design and form of project MACIMISE itself evolved in response to the participants' experiences, cultures and contingencies. A standard dissertation form would, in my view, have made it difficult to accommodate these variables.

My solution has been to adopt a personal narrative format for this dissertation. In so doing, I attempt to honor the cultural distinctiveness of Pacific Island cultures and to adapt to the evolving nature of a project as unique as MACIMISE. Therefore in Part II: Participants' Voices, I attempt to tell our story (although to be honest, it can only be my interpretation of our stories) through excerpts of our ongoing conversations and written documents in six chapters. And in Part III: One Last Circle, I begin by inviting you to join us in a "circle" with excerpts from some of our last conversations in spring and summer of 2013.

I believe that presenting the study in this way is more compatible with the orientations of the participants, many of whom are highly removed from formal academia. I sought to assemble the parts of this dissertation to tell a story rather than follow a blueprint, and I strived to "present the information in this study in a way that is more culturally appropriate for Indigenous people by taking the role of a storyteller rather than a researcher/author" (Wilson, 2008, p. 32) I attempted to approach this more holistically by considering interrelationships among self and things rather than individualizing things or setting up subject/object dualisms. In summary, I found the conventional dissertation to be an inappropriate form for capturing the richness and situational responsiveness of this study.

CHAPTER 2

GRAPPLING WITH DEFINING THE RESEARCH AND MY ROLE IN IT

Synthesizing to Discover My Research Paradigm

I struggled to couple my numerous personal lenses with the underlying beliefs and assumptions that define dominant research paradigms. First, I combined aspects of critical theory and constructivism. The critical theory aspects are that

> …the material world is made up of historically situated structures that have a real impact on the life chances of individuals. … it is assumed that knowledge is always mediated through the political positionings of the researcher. … [the methods] require dialogue between researchers and participants that can lead to social change that transforms the lives of the participants in positive ways. (Hatch, 2008, pp.16-17)

It was my hope that you, the reader as a participant, will read this study and in some way be transformed as you consider the ways the various constituents—MACIMISE participants, instructors, consultants, teachers, students, administrators, local elders and experts, parents, local mathematics curricula, ethnomathematicians and perhaps even mathematicians—have been or may be affected as we interacted with MACIMISE.

Wilson (2008) provides a summary of constructivism that captured my intentions as well.

> Constructivism takes the ontology of a fluid reality [in critical theory] one step further in the belief that there is not merely one fluid reality, but many realities specific to the people and locations that hold them … with reality made up of

> socially constructed concepts that are shared. … The methodology stresses an interaction with the subjects to elicit and refine this mutual reality through dialogue that compares and contrasts each other's constructs of reality … with the aim of the research … to come to a consensus among researcher and subjects on a construction that is better informed than it was before. (p. 37)

Each of us, including you the reader, are both researcher and subject as we participate in this dialectical experience. Our experience, our relationship with what is presented through this research, begins with our perceptions. Our perceptions are the result of our personal histories, shaped by where, when and how we have lived. As researchers and subjects we will interact with what is presented to us in a way that is limited by our perceptions. However, our relationship with our perceptions, the ability to notice and possibly challenge them is at the heart of this research. By questioning our perceptions and engaging the resulting uncertainty, we may be able to move beyond what we initially see and want to see to new constructions of realities.

In this way this research is also rooted in indigenous thinking. As Wilson (2008) describes:

> Basic to the dominant system research paradigms is the concept of the individual as the source and owner of the knowledge. These paradigms are built upon a Eurocentric view of the world, in which the individual or object is the essential feature. This premise stands in stark contrast to an Indigenous worldview, where relationships are the essential feature of the paradigm. (p. 127)

I am asking you here to forget considering who you are, what you know and what the research is presenting and instead ask how these facets relate to each other.

> Rather than the truth being something that is "out there" or external, reality is in the relationship that one has with the truth. … that reality is the relationships or sets of relationships.…reality is not an object but a process of relationships. (Wilson, 2008, p. 73)

It is my view that relationships show themselves as circumstances and participants become open to and allow them.

In summary this research is what Kathleen Berry calls "bricolage" (Tobin, 2006). Because of the various features of MACIMISE and because the nature of the experience was organic and dynamic, I found that the research needed to be as well. As Dawson, Project MACIMISE leader had said, we were "creating a path laid by walking." I used many different tools as they presented themselves. I collected many different accounts without knowing exactly what parts would be used, and "the resulting interpretive method can be viewed as a bricolage, an emergent construction that changes and takes new forms as different tools, methods, and techniques are added" (Kaomea, 2000, p. 321). It is also for these reasons—the self-generating nature of relationships and the ever-changing emergent constructions—that this dissertation does not follow the typical format.

Types of Qualitative Research from the Dominant Perspective

First to provide some clarity, when I refer to a "lens," I am referring to what an individual is able to perceive because of their personal histories and experiences. These

lenses can only be seen through each individual person; it is part of their identity and how they are able to perceive the world and events in it. These can rarely be communicated to and truly understood by others. In contrast, when I use the term paradigm, I am referring to a more generally accepted and "coined" way of creating and interpreting constructs through which people, in general, may attempt to look at and perceive the world and events in it. A lens is personal and can only be known by the individual whereas a paradigm has the possibility of being similarly perceived by others.

As I described in the previous section, I found it challenging to label the research paradigm. Equally difficult was labeling the type of qualitative research I have conducted. This study is partly autoethnographic because, as a participant-observer in MACIMISE, I continually reflect on and explore my perceptions and experiences, connecting my personal history and subjecting it to scrutiny. This adventure has helped me understand myself and use my changing self as a lens for understanding what others have gone through.

My research is also ethnographic because I "seek to describe culture or parts of culture from the point of view of cultural insiders" (Hatch, 2002, p. 21). In this research, one culture was that which was created within the group of MACIMISE participants. However, there are layers upon layers of other cultural groups: parents, teachers, colonized, colonizing, children, students, indigenous, Western, ethnomathematicians, mathematicians, and so on.

Finally, in the spirit of bricolage, I use aspects of interview studies, focus group studies, artifact analysis, symbolic interactionist studies, narrative studies,

phenomenological studies and case studies, as defined by Hatch (2002, pp. 23-31) and (McMillan, 2004, pp. 260-277).

Finding My Role as a Researcher and Participant

Now that I have attempted to "define" the type of study this is (the Western part of me loves definitions; it makes things seem simpler, more contained, more predictable and thus more controllable than they are), I go back to my indigenous roots.

Wilson (2008, pp. 80-96) describes that essential to an indigenous research paradigm are relationships—relationships with people, with the environment and land, with the cosmos. Like Wilson, "My intention was that through seeing this relationship unfold in the text, you would also form a relationship with me. The relationship we form is an elemental component of an oral tradition and is generally missing from written text" (p. 126).

And so here is where I must begin to allow you in. To allow you to know me a bit so that you might be able to understand how what I portray through this story is greatly influenced by my life, my experiences, my challenges, my aspirations for self, for others, for the world. It is inevitably seen through and interpreted through my many lenses.

"An important component of mathematics education today," writes D'Ambrosio (2001), "should be to reaffirm, and in some instances restore, the cultural dignity of children" (p. 308). My own mathematics education was anything but culturally dignified. And from what you read in this research, you may find other participants feel the same.

Who I Am

I was born on Maui and raised on O‘ahu, and like many Hawai‘i children, I am hapa: my father is Hawaiian and I look like him: dark brown skin, hair and eyes and Polynesian features. My mother is a Caucasian (or “haole” as we say in Hawai‘i) and blond haired. My mother left my father when I was three years old. I grew up as the only dark-skinned person in my mother’s haole family. To my peers, I was neither haole nor Hawaiian—I didn’t feel I belonged anywhere. Wherever I went, I felt an outsider.

For me, Hawaiian culture existed only as a vague background, a setting for the drama of a different, later-arriving culture. As the only dark-skinned member of my family, I was always aware of my difference, straddling the two worlds yet fully part of neither. I attended public school on the Windward side of O‘ahu (Kailua, Kāne‘ohe), where I was offered a Western-style education that seemed impervious to the place in which it existed. I didn’t learn ‘ōlelo Hawai‘i (the Hawaiian language), nor was I introduced to Hawaiian spirituality, culture or mathematical knowledge in anything other than a cursory way (for example, learning to count to ten in Hawaiian—an irony, since it’s reported that Hawaiians counted by fours and its multiples).

Neither did I learn anything of my indigenous heritage; as a K-12 student, I was taught a Westernized Hawaiian studies curriculum that both obliquely and directly denigrated Hawaiian history and culture. I was too young to understand the post-colonial dynamics underlying these attitudes toward native people. I did not understand why locals were thought of as stupid and why speaking Pidgin was discouraged. I felt inferior to my white family. I grew to be ashamed of my dark skin, wishing I were white like the

rest of my family. I remember being about eight years old, seeing a gecko (local lizard) that had died in a swimming pool. He had turned from brown to white, and I asked my grandmother "If I stay in the pool long enough, do I get to turn white?"

I had recently turned 19 in January of 1990 when my grandmother looked at me with sadness and said, "Sweetie, I'm so sorry that you'll never go to college." It's understandable why she'd say that; I'd come from a family devastated by divorce, addiction and abuse, and no one had ever been to college before. We were desperately poor and college seemed an impossible, unaffordable dream. But the next day I took the bus to Windward Community College, applied for a Pell Grant and enrolled a couple of days into the spring semester. Twenty-some years later, in 2013, I'm not only the first college graduate from my family but I'm writing this dissertation.

While attending college, I worked in the visitor industry, first as a sales representative for a tour company, then as a front desk clerk in a Waikiki hotel. It was part of the Western paradigm, where brown-skinned local people, or immigrants from places like the Philippines, worked low-paying jobs servicing a tourist industry catering to more wealthy foreigners. But I was always searching. I transferred from community college to UHM, where at the end of the one required Hawaiian Studies class, the instructor, a native Hawaiian, pulled me aside. He praised the quality of my writing and asked what I planned to do; I told him I was pursuing a bachelor's in mathematics (I later switched to elementary education). He encouraged me to continue, saying that Hawaiians were underrepresented in advanced careers. I never forgot that moment; I was proud, a feeling I rarely had before.

It has been only in the last decade that I've reconnected with a bit with my Hawaiian side, dancing hula, studying lā'au lapa'au (plant healing) and practicing lomilomi (I am a licensed massage therapist). I've begun studying Hawaiian language. I've educated myself about Hawai'i's troubled postcolonial history, during which Polynesian ways of thinking—which have much to offer a Western civilization in dire need of revitalization—nearly died. I owe my renewing sense of identity to those who came before me and fought to keep the culture alive; it's my wish to participate, in some small way, in returning these ancient ways of knowing to Hawai'i's children, to maintain the cultural dignity essential to a healthy, sustainable and peaceful future for the people of this 'aina (land) and all of the Pacific. Only by participating in a culture can one build respectful relationships between self and others.

I believe the reason Hawai'i's children, particularly native Hawaiians, as well as children across the Pacific consistently underperform in mathematics is not because they are any less capable than their Mainland counterparts; it's because the curriculum they're being offered isn't meaningful. In addition, they live lives full of stories like mine, some a little less difficult and some much, much more. All, to different degrees, with indigenous values that are often in direct conflict with the dominant consumer, capitalist, competitive, exploitive, unsustainable growth model.

Knowledge informs behavior. One of the original goals I had when entering project MACIMISE was to become knowledgeable about the different cultures represented in the project to establish respectful relationships between myself and the other participants. By listening with an open heart—the mind by nature is obtrusive—to

the stories of those I researched with, I attempted to respectfully and humbly relate to the other participants in MACIMISE to construct what I perceived to be a set of shared understandings and ideas. Our Pacific cultures have common stories, yet we are each unique.

By collaborating and studying with research participants about ways of being and living with the natural, socio-cultural and academic realities both past and present, it has been my goal to shed light on the MACIMISE journeys of discovering traditional and local mathematics, integrating various perspectives, investigating how the perceptions of people, from the youngest to the most elderly, lead to the transmission and transformation of a culture. In this way, mathematics may go from something to be endured to something to be celebrated and enjoyed; not dry recitation of formulae, but a vibrant and practical expression of living culture.

The Pacific is a region where indigenous people still survive. It can be a place where cultural dignity thrives and is passed on to its children. And if I do nothing else, I want to be an example for my four-year old daughter, to show her that we, Hawaiians, Polynesians, the indigenous, have something to say.

Some Resulting Biases

To summarize, some lenses I look through when interpreting my data are: me as a Western colonizer, me as a colonized Native Hawaiian, me as a poverty stricken child, me as a child of addicts and abusive parents, me as a survivor, me as an empathetic mother of all children, me as a seeker of knowledge, me as a worker in the hotel industry, me as a consumer, me as hating being a consumer, me as appreciating the opportunities

available in my mostly Western society, me as being limited by my mostly Western society, me as a struggling mathematics student, me as a mathematics teacher, just to name a few.

This study therefore includes multiple biases. It is limited by what I am able to perceive. It is also limited by what other participants are able to perceive and what they were willing and able (we have different first languages) to share with me. However, despite the biases, I argue that this study it is extremely valuable for several reasons. It attempts to tell the story of what happens when Pacific islanders explore aspects of their cultures that have often previously been unexplored by them and others. It tells what happens when indigenous people attempt to resurrect and revive their culture. And it describes challenges and triumphs when they try to position their home cultures in formal academic environments so that their local students might show improved mathematical success. In this study, I define success as something not limited to better test scores but that which includes greater motivation and self-efficacy in mathematics.

CHAPTER 3

STRUGGLING TO FIND A WAY TO APPROACH THE STUDY

Initial Questions, Participants and Data

From January 2010 to May 2013, we came together as a MACIMISE family in many different contexts. We took our first class together in January of 2010. These synchronized (live, on-line) classes continued through May 2013. Outside of the scheduled Blackboard Collaborate sessions, we met in small groups to complete various class projects using additional technology platforms such as Skype, Laulima, "The Learning and Collaboration Server for the University of Hawai'i Community" and Facebook. In addition, during summer institutes, usually lasting one to two weeks, we met to attend and teach classes, attend and present at conferences and for other MACMISE meetings and gatherings.

Using the recordings from selected experiences and my personal journal with notes and reflections from those interactions, I planned to use constant comparison approach to analysis as themes emerged over time, seeking to describe patterns of behaviors the participants used in making sense of their journeys to form generalizations, exploring similarities and differences among the participants (Hatch, 2002, p. 15). I used that data to inform how I would conduct surveys and interviews with twelve participants. From their responses, I planned to do four detailed case studies with two masters and two doctoral degree candidates from different islands so that my data could include aspects from what were, in some instances, very diverse societies and communities. My original research questions were:

1. What are the personal journeys of participants in their study of traditional and local mathematics?
2. What trends emerge among the participants' journeys? Are there similarities and differences among the different locations and cultures?

By July 2012, I chose the four participants to focus on during the last two scheduled years of Project MACIMISE (August 2012 to August 2014) who were from different islands and whom I believed had varied previous experiences and expertise. After conducting initial interviews in August 2012, the selected participants and I developed a schedule for follow-up interviews using the most appropriate and available communication technology (Blackboard Collaborate and Skype). I endeavored to interview and survey those participants monthly. I also hoped that we would assist each other as we completed our research and curriculum projects. At the conclusion of our journeys, I hoped we would engage in "relational accountability," as Wilson (2008) describes:

> My role, based upon the guidelines of relationality and relational accountability, is to share information or to make connections with ideas. The ethic in place is that it is not right to interfere with another's actions or thought process—that would not allow them to be accountable to their own relationships. (p. 133)

To engage in this indigenous form of "validity," I planned to share my transcripts along with my interpretations with the four participants in hopes that we would examine them along with our products (research and curricula) together to engage in "Indigenous discourse" which as Wilson (2008) describes "is to provide a foundation or platform from

which to grow, without putting a ceiling or limit on the direction of that growth" (p. 135). With each of us as participant-observers, we would be co-constructors of our research, and I would humbly strive to tell "our story."

As often happens in qualitative research, my research plan changed. It proved too difficult to sustain consistent conversation across the Pacific. First, participants were often unavailable during scheduled meetings; their lives were full with work and family. Second, coordinating across time zones proved difficult and the communication technology was not always reliable when we were able to. Third, participants were usually at different stages of the journey. For example, one participant might be working with local experts, another might be writing the lessons for their unit and another might have piloted their unit already. Questions designed for interviewing one participant were not always appropriate for another. I had to revise my data collection methods.

What My Actual Research Questions Became

We took our first class together in January of 2010. Recordings and documents from that class and all subsequent classes were available data. In addition, beginning in the summer of 2011, there were video and audio recordings of some small and large group discussions. I decided that I could examine them, along with subsequent naturally arising situations, to answer slightly different questions. Rather than examining the personal journeys of just a few MACIMISE participants, I could look at the data collected over time from different settings and situations while also including a greater number and wider variety of participants.

My research questions evolved as I was transformed by my experience as a MACIMISE participant and researcher to become:

1. What happens when participants in project MACIMISE study traditional and local cultural practices to uncover indigenous mathematical ways of knowing?
2. What happens when they attempt to create mathematics curricula based on cultural practices and try to implement them in local schools?
3. What are the similarities and differences when the participants share about their experiences?
4. How can we use these discoveries to inform future projects with goals similar to MACIMISE?

These questions were more open-ended and allowed for more divergent data collection. I could answer, for example, what happened to a particular participant, what happened with several participants or what happened to MACIMISE as a whole. I invited all MACIMISE participants to be a part of my study at various times up until May of 2013. In the end, I collected data from eighteen participants (including myself) at different times and used various data collection methods described next.

Strategies of Inquiry ≈ Research Methods

Wilson (2008) summarizes my own approach to data collection:

> … it may be appropriate to change the traditional positivist language of "research methods" to look more at "strategies of inquiry." The choice of strategies that I used in this study depended on the questions that I wanted to ask, upon the context of the study, upon the resources available to me and

> finally upon what I could do in the setting where the study took place. By using the term "strategies of inquiry," I am implying that one specific research method would not fit the subject being studied. Instead of writing down one (or several) chosen methods and planning to stick to them, I developed a general strategy of where I wanted to go. This strategy needed to allow for change and adaptation along the way … I hoped to remain open to any change that the situation required. In addition to the process changing in order to achieve the end goal, the end goal also changed to meet the emerging process. (p. 40)

I had to remain similarly flexible. My strategies of inquiry changed as I engaged in them. For example, I was doing a small group interview in Palau in the summer of 2012 when I heard a few MACIMISE participants on the other side of the room discussing some struggles they were having. I asked those participants if we could join for lunch; the result was a rich discussion. We spent the next hour "talking-story" about gender issues, curriculum development issues and local counting systems. It was a chance conversation, outside the intended research parameters I'd set forth but just as valuable if not more so. This is only one example of what Dawson had said in one of our first circles in the summer of 2010. "We have embarked on a path, and the path is laid down as we walk the path." I often had no idea where the path was leading. I was not the only one: Several other participants shared that they were often confused about what they were doing and why they were doing it. A participant from Pohnpei shared the following while reflecting in 2013 on the journey in MACIMISE:

> When I first got into the program, I didn't really know what was expected of me. I

> had a sense that I would be developing units. I just started taking the classes. I didn't know the program and that the classes were connected. As I took more classes, I found out that the classes were to help develop the mathematics that would be used to create the units for the MACIMISE project. … At first I was not really sure what sort of activity to do for my classes, and as I took more classes from UH, I began to understand the mathematics and the research methods classes and it began to make things clear for me.

As a participant-observer taking part in the day-to-day activities over this long period of time, I gained a closeness and familiarity with the group. By "watching and doing in a scientific way" (Wilson, 2008, p. 40), I observed others and myself as we engaged in the various aspects of MACIMISE and in the subsequent personal reflections and discoveries. We were co-creating not only our program, but our own sense of what we perceived the project's aims to be. And this co-creation often emerged from our relationships and our most informal interactions.

The first time we met as a group in Saipan in the summer of 2010, we started with a "circle" and we began "talking-story," two indigenous strategies of inquiry. "Talking circles, while not a new idea for Indigenous people, are newly being accepted as a research technique" and are similar to focus group discussions (Wilson, 2008, p. 41). In our circles, a talking stick was passed from one participant to the next, and was passed around at least twice. Whoever held the stick had an uninterrupted turn to share feelings and ideas or address specific prompts or questions. A participant could choose to pass the stick if they were not ready or decided that they had nothing (more) to share. This

permitted a freedom of expression that allowed speakers to discover what they meant to say through the process of listening, reflecting and speaking. Both circle and talk-story sessions (described below) are based upon an ideal of respect for the participants. "Circling facilitates the transference of responsibility from a leader to the participants. …Working within circle engenders an environment of 'hosting' rather than one led by 'heroes'" (Dawson, 2012, pp. 7-8). Circles were held at least twice every time we met face-to-face in the summers, sometimes daily, and most on-line classes began with a short circle where each person "checked in" and gave a personal update.

A more informal research strategy, called "talking-story" in Hawai‘i, happens when a pair or small group of people sit for a conversation. Hanohano (2001) describes that "The purpose of Talking Story is to mentally, emotionally, and spiritually reach across…to try to understand the other person's perspective…we speak to understand, not to be understood" (p. 88). There might or might not be a particular topic; topics tend to arise in an unpredictable fashion. It is difficult, even if a topic is intended, to predict whether the topic will be directly (or even indirectly) addressed. Talking-story can be circuitous, discursive, nonlinear, even full of seeming non-sequitur. This form of communication might fluster a Western researcher accustomed to linear question-and-answer dialog. Indeed, I myself have been flustered when interviewing one Native Hawaiian elder. During the interview, I remember thinking that the conversation was going nowhere and that it had gone terribly. It wasn't until later, when I reviewed the audio recording, that I realized what I had missed. I was amazed at what I learned when I wasn't listening for what I thought I wanted to hear.

Talking-story is sometimes elliptical, oblique, metaphoric and meaning is often derived more through form than from content. It can be exhausting if you are looking for something specific and energizing if you are not, if you can allow it to just happen and provide its own form. The direction of the conversation is organic and may depend on rapport with the interviewer, who is not an interrogator but rather an equal participant. Questions likely to begin a talk-story session are: How's it going? Where are we at? Much of what arises when talking-story might be only loosely relevant to the "topic," but there is also increased potential for surprise and spontaneity. I had approximately twenty talk-story sessions with approximately ten participants at different times from 2010 to 2013. Sometimes it was just two of us and sometimes there were up to five of us.

The previous two research strategies honor indigenous approaches to knowledge and communication shared widely by cultures throughout the Pacific. However, I also relied on more widely used forms of data collection. During spring of 2011, I surveyed sixteen participants about their perceptions, participation and progress in MACIMISE. See Appendix A for the survey questions. I received responses from four participants.

I also conducted individual and focus group interviews. The interviews had more prescriptive topics and questions than talk-story sessions; they permitted me to attempt to "lead" the discussion rather than allow things to unfold. For example, in the summer of 2012 in Palau, I conducted five individual interviews. The questions I designed are in Appendix B. Although I had the planned questions for individual and focus group interviews, sometimes the interviews turned into talk-story sessions depending on the topic, participants and how the participants interpreted and responded to my questions

and prompts. For example, one focus group consisted of two participants who were working together on the curriculum units for their island group. I began with my planned questions, but we ended up spending all of the time discussing just the struggles we were having while trying write the lessons for our units. Some focus group interviews were planned. Others arose when an issue surfaced as people worked together or even just shared a meal.

In the last interviews, planned to be "final focus group" interviews conducted in Honolulu in May 2013, I attempted to organize groups of participants by where they were geographically implementing their units. The interview questions are in Appendix C. However, because not all participants were available at their scheduled times, the construction of the groups changed. Therefore, when we met together, rather than having each participant respond to each question, I allowed them to choose the questions to which they wished to respond, to which they "most connected with." I ended up meeting with sixteen participants in mixed groups of between one and six people at a time. In this way, this intended "formal focus group discussion" became more talk-story sessions with different participants at different times.

In addition to all of the previously described data sources, I also examined written documents. For example, in January 2010 participants wrote "Journey Stories" describing themselves, their academic histories and their reasons for joining MACIMISE. In May 2010 participants completed a research paper describing cultural activities in their home locations. During our synchronized courses held from 2010 to 2013, participants prepared visual/textual presentations to support oral presentations. Doctoral students completed

comprehensive exam questions (Appendix E) and submitted them in writing in July 2012. Lastly, in May 2013 all masters degree candidates completed their Plan B papers describing their feelings and experiences regarding being in MACIMISE and creating their curricular units.

I had recordings of most Blackboard Collaborate sessions, including online classes and Plan B "conversations." Additionally, I recorded some circles and talk-story sessions, all of my formal, and some of my informal, individual and focus group interviews.

Data Analysis

I transcribed the recorded circles, talk-story sessions, interviews and some Blackboard Collaborate sessions. I did first cycle coding of transcriptions using in-vivo, descriptive, value and versus coding as described by Saldana. See Appendix D for a sample of my first cycle coding. As I coded, I kept an analytic log and compared that process to the reflections in the journals I kept throughout the project. (Saldana, 2012)

From the first cycle of coding, approximately fifty codes emerged. I attempted to combine codes I thought were examples of similar ideas, concepts, feelings, beliefs, reflections, etc. From these, themes began to immerge. One theme for example was "Outsiders Looking In and Insiders Looking Out." This theme was generated easily from an in-vivo code, a quote, that a participant shared in one of our first circles in Pohnpei in 2011. In this theme, I explored the various ways participants considered themselves outside of a cultural group while trying to navigate their places within that cultural group and vice versa.

Once I identified a theme, I scoured all transcripts and documents for additional occurrences of the theme. I then repeated that process for other themes. At times a theme would emerge, and as I sought more evidence to confirm the theme, the theme would disintegrate, morph or be absorbed into another theme. For example, one versus theme I originally identified as "Traditional vs. Western" became absorbed into a broader theme I termed "Culture and Language Matter." I elucidate each major theme as chapters in Part II: Participants' Voices. However, in Part III: One Last Circle, I move away from trying to code and label themes to instead present parts of conversations and documents from the last few months of data collection (January through May 2013) so that you might join us in a conversation and possibly form your own relationships with us and what we shared.

Limitations of this Study

There are several limitations in this study. First, as a participant-observer and the researcher, my lenses limited me. Second, the data shared by the participants is only what they were willing to share. They may have had thoughts, values and beliefs they chose not to offer. Third, many participants had languages other than English as their first language. I was unable to understand all participants because of some heavy accents. In some interviews, I had to leave large sections out because it was inaudible or I could not understand what they were saying. Fourth, due to our different languages and cultures, while researchers believe that they are asking particular questions, these questions are not always perceived by the listener as they were intended by the interviewer. Similarly, when answering a question, the person receiving the answer might not have been really

"hearing" what the person sharing was intending them to hear. Finally, Saldana (2013) in *The Coding Manual for Qualitative Researchers* describes that coding is subjective. Others may have coded the data differently, thus generating different themes and conclusions.

PART II

PARTICIPANTS' VOICES

CHAPTER 4

MOTIVATIONS FOR WANTING TO JOIN MACIMISE

The stated goals of MACIMISE were threefold. First, participants were to examine local cultural practices to rediscover and/or uncover indigenous mathematics through working with elders or other experts in their communities. Second, they were to develop, lead the implementation of, assess and refine mathematics curriculum units based on these cultural practices for grade one, four and seven students. Third, the project aimed to build local capacity by offering advanced degree opportunities. In conversations and some documents, participants shared about why they were interested in being a part of MACIMISE. What they shared was indicative of their personal and professional goals as well as their perceptions of the goals of MACIMISE. Many were interested in joining MACIMISE because of the cultural dimensions of the project as well as the opportunity to earn an advanced degree. I begin with the story of how and why I got involved.

I received e-mail in September 2009 from Dawson, the project director. “We are launching a Masters/Doctoral program that focuses on indigenous mathematics across the Pacific region. Any interest in pursuing that possibility?” My immediate response was “yes.” I was definitely interested in a doctoral program. I met with Sandy a couple of weeks later. We discussed the reasons why I was interested in being considered for MACIMISE. I shared that growing up the way I had, being a part-Hawaiian living in Hawai‘i and raised by haole, left me feeling divorced from and longing for connection with native, traditional and indigenous knowledge, language and practices. The only cultural activity I was introduced to and participated in fully while growing up was

making Norwegian pancakes, crepes, for Christmas morning. I'd always felt like an outsider from all of my ethnicities (I am Hawaiian, Chinese, Portuguese, English, Irish, French, Dutch, Norwegian, American Indian and German)—a cultureless, shell of a person. I was also pregnant at the time, expecting my first (and only) baby in January of 2010. I wanted to be better equipped to provide her with a more purposeful and authentic Hawaiian experience. I felt a need to connect with my roots not only for myself but more importantly for her. At the end of our conversation, Sandy shared that the project was funded by the NSF and would not cost anything to participants. I was shocked. Really? Could this be possible? A free doctoral program? It became even more attractive, if that was possible.

Like me, many who heard about the cultural underpinnings of MACIMISE were immediately attracted. A participant shared:

> I ran into Sandy. He told me about it and asked me if I was interested. Immediately I said "yes." I had experience with ethnomath in a masters course…[an] article I really liked and did a lit review on it. But it was all about foreign ethnomathematics.

When I asked what the participant had hoped to gain, the response was:

> To learn more about teaching mathematics. It was another step in learning to teach math and second, it was a field that I was interested in. I look at math as boring to kids and it's a way to get kids interested. I'm always interested in kid's motivation, and liking math, and making math more relevant. That's why I really liked it.

Many participants shared the belief that children would be more motivated to participate in mathematics if it was related to their local culture.

For those of us who had not been part of DELTA or MENTOR, two previously NSF-funded projects, the motivations for wanting to join MACIMISE were a desire to be involved with a project that focused on our home or local cultures, the possibility of linking those local practices with content and practices in formal mathematics education environments, and the opportunity to earn a degree. A participant from Yap shared about having recently moved from an outer island to the main island in the particular island group and had not known anything about the previous two projects. “I was working and my boss came in and said somebody is coming around from the states asking for people to participate in a project and at the same time get their degree. As soon as I heard that the project was related to culture, I became so interested. I’ve seen that students are learning from textbooks instead of using cultural activities for math.”

For many of us in the Pacific, there are few opportunities for advanced degrees and the cost is often prohibitive. For example, a Pohnpeian participant had heard about MACIMISE a year before the project began, but didn’t apply because of the cost of tuition. It wasn’t until later that it was learned that NSF was funding the project and the participant attempted to join. This participant wanted to join MACIMISE because of the “intentions of the project on the flyers.” In addition to the lack of opportunity, mainstream academic programs generally privilege dominant Western education content and methods. The educators who wanted to join MACIMISE had noticed that local ways of living were mostly absent and disconnected from academic environments.

Some participants had been a part of one or both of two previously NSF-funded projects, DELTA and MENTOR. For the participants who had been involved in DELTA and/or MENTOR, along with the cultural dimensions of the project and the opportunity to earn a degree, there was a desire to join because of the cultural sharing aspects in the first two projects and how an ‘ohana (a family) had been formed. A participant from Chuuk shared:

> There was a gap of two years at the end of MENTOR when we were waiting, although we didn’t know what it would be. We were excited and anticipating the next project because of the first two programs. I needed to be in MACIMISE because of the family that was built. I was expecting it to continue into MACIMISE. And there was the opportunity to finish a degree, which we didn’t have in the other programs, the lure of a degree.

In January of 2010, a participant from Samoa wrote about the academic journey before MACIMISE. “It is my intention to further my education and obtain a Masters Degree in education. I realized early on in life that education is the path to success.” This participant had been in both DELTA and MENTOR and as a result of being in those programs, personal views about education had been greatly influenced. These included using more problem solving, revising lessons based on how students perform, cooperative learning as one of the primary instructional methods and improved questioning techniques. Upon learning about the project, this MACIMISEr shared:

> [I] immediately saw a great opportunity to further my education and contribute to the overall education system on my island as well as other Pacific islands. The

> involvement of the cultural practices in this project is again another opportunity to share the richness of learning resources in our cultures.

Later, in Palau in 2012, this project member also shared:

> My goal is to change the whole mathematical system within the department of education. And I know it's long term with a lot of obstacles. I had that goal in mind when I came through project DELTA, MENTOR and now MACIMISE.

Two other participants also shared how they hoped in various ways "to get the teachers' buy in and then the parents' because they will have the political influence."

At the time of this paper, twelve participants have earned their masters degrees and ten doctoral students are at various stages of completing their dissertations. The latter part of project's third goal, offering advanced degree opportunities, has been accomplished. The other two goals are the focus of most of the discussion in this research because they have been more difficult to achieve. They are filled with nuance and contradiction.

CHAPTER 5

PERSONAL ACADEMIC HISTORIES

"My thinking was that math curriculum was ancient, foreign and irrelevant."

At various time during MACIMISE, participants shared about their experiences as elementary and high school mathematics students. Many shared that they had teachers who either were not good at teaching mathematics, taught straight from textbooks, or who skipped mathematics altogether. They reported that their teachers were poorly trained and as a result, many of their mathematical experiences in school were negative.

One MACIMISEr shared that "mathematics was one of the subjects that was neglected by teachers…I had a teacher that did not even bother to talk about math even during the time allotted for the subject." Having gone a year in elementary school with no mathematics instruction, this participant struggled the next school year, being very far behind. Another participant shared that, during high school, "teachers taught straight from the textbooks, students took notes, practiced with a few problems, were quizzed, and then were given an exam." Just one participant shared about a teacher who brought mathematics to life by relating it to local environments and artifacts.

As a result, there was a common belief that mathematics teaching consisted of, as one MACIMISEr shared:

> strictly numbers, memorization of multiplication tables formulas and graphs. My thinking was that math curriculum was ancient, foreign and irrelevant to the

> [local] culture. It has always seemed to me that math was a Western introduced way of thinking to quantify things.

Another participant shared that "I always held the notion that mathematics was for a very few people who think differently from the rest of the world." They reported a belief that mathematics was "stagnant."

As a result of having poorly trained teachers and teachers who were not competent mathematicians or mathematics educators, many participants disliked mathematics and did poorly as students in mathematics classes. Mathematics did not make sense to them.

> I, like many other people in this island nation [am] afraid of mathematics due to the fact that we never succeed in any mathematics instructions, assessment, evaluation…I have failed many mathematics classes from elementary all the way to [the] two year college. I even had to take a remedial course so that I can take advanced college mathematics. Being an elementary school teacher, I believe I taught my first and second graders mathematics just the way I learned.

Mathematics instruction "remains the same" today.

MACIMISErs also shared what they saw when they observed modern classrooms; they reported that little has changed. As often happens, teachers teach as they were taught. Therefore, those that became teachers or teacher educators reported initially teaching in the same way, through textbooks and step-by-step procedures. They reported not being strong in mathematics; they then continued to teach children in the same rote, algorithmic ways, teaching their students, in the words of one participant "my way" of

problem solving and the participants reported that their students were bored, unmotivated, and could not recall prior knowledge nor make connections between the content that was taught in different lessons.

MACIMISErs who observed teachers in the field as part of their profession reported that mathematics instruction "remains the same." Teachers continue to teach from the textbook in rote ways. Some also shared that the content and activities in the texts

> include visuals and words that are not relevant to the children's environments in these small islands. I think this is one major component that causes low student performance and loss of interest not just in mathematics but [in] other subject areas as well. Other factors might include competence of teachers and students in the language the books [are written in].

As a result, participants often shared that many students come up through the grade levels without the skills and knowledge they expected them to have learned from the previous grade. This problem seems systemic and not restricted to any particular geographic region. "The teachers still give handouts even though we have Singapore Math," said one MACIMISE participant. "We pass out a lot of handouts, and the kids do paper and pencil [mathematics activities]. … Teachers have to shift teaching to have more hands-on. … We don't have them practice mental math." I found it to be similar in Hawai‘i. Children often complete worksheets and handouts, having little opportunity to communicate and represent mathematical ideas meaningfully with written and physical models.

Two participants shared that there had been efforts by their governments and educational leadership to begin to include curriculum to address some local language and culture that had not been addressed before. However, this was only in content areas other than mathematics.

"None of my supervisors ever asked me if I had any experience in teaching."

Many MACIMISErs had been or were teachers and shared about what it was like when they first started teaching. Some who were hired as teachers reported that they themselves were not trained as teachers, and if they were, they received little support as new teachers of mathematics. As a result they continued the textbook instruction because that was all they knew.

> I was fresh out of college and did not know much about being a teacher. I expected to get a formal job orientation from the person who was the chairman of the mathematics department at the time, but to my surprise, he did not think that it was necessary. The only form of orientation I got from him was being given the textbooks for my classes, shown where my classroom was, and introduced to a group of students as their new teacher.

Another participant, who had not received any training or education for teaching, got a first job as an elementary school teacher.

> I did not know the first thing about lesson plans, curriculum, and effective teaching strategies…None of my superiors ever asked me if I had any experience

> in teaching…They were mostly just glad that I had a degree and was willing to teach for the amount they offered.

Those that were formally trained in mathematics reported perpetuating the same kinds of instruction they received as students. In spite of being a high school mathematics teacher for over a decade and a college mathematics instructor for almost a decade, one participant reported that the result of having received only teacher-directed and textbook-based instruction as a student was a belief that teaching mathematics "only entailed transferring knowledge from one person, a teacher, to another the student." Another participant, while an elementary teacher of mathematics, skipped the pages and lessons in the textbook when the content or language was not personally understood. In summary, students and their teachers were not actively making meaning of mathematics or mathematical experiences. They believed that mathematics was foreign and that their local cultures did not have mathematics. It was brought to them in textbooks.

The MACIMISE participants who were teachers expressed that they themselves were are weak in particular content areas that they were teaching. A teacher in MACIMSE expressed, "I always learned mathematics through the approach that teachers come with procedures, formulas and they just give us something to memorize," said one participant, and who through being in MACIMISE, this participant discovered through MACIMISE that "the way I learned mathematics wasn't really complete." I argue that for most of us, the way that we learned was not complete. Most of us were presented with step-by-step formulas and algorithms with little to no attention given to what was happening and why it was happening while performing them. Yet another MACIMISE

teacher, who was working with first and sixth graders, and who also had experience working with third and fourth grade students, admitted, “I always depended on the text. … I didn’t know about other ways to talk about and teach mathematics.” This phenomenon’s not limited to elementary through high school teachers. “I haven’t really tried these cultural approaches,” at the post-secondary level, shared one participant. The college “has its own policy of teaching. They make us use textbooks.”

CHAPTER 6

CULTURE AND LANGUAGE MATTER

"A tree won't grow high without very deep roots."

After meeting in consultations group in Pohnpei in 2011, we met in a large group circle to share. We were grappling with issues surrounding the teaching and learning of mathematics and how they may relate to culture. A consultant summarized what a participant had shared in a smaller consultation group earlier in the day. "Cultural identity is what establishes the roots of the child." Culture is part of how "people ground themselves and establish their sense of self and sense of identity." The experience of learning the mathematics of another culture, without a firm understanding of one's own culture was described as problematic. "We can build towers of Western mathematics" but if a child does not have a firm grounding in his or her culture, it will topple. The consultant used mix metaphors.

> A tree won't grow high without very deep roots. Or if the tree can grow high and has really shallow roots, what happens? They topple. In any storm, the tree comes down and creates a lot of damage. A lot of our children are getting built up on foreign, Greek mathematics…We're building up these tall towers, and growing tall trees with no roots, and what happens is, they topple. You can't have the Western mathematics without the cultural roots. It won't be useful. It won't be purposeful.

From my personal experience of growing up separate from any particular culture, neither ever fully a part of my Hawaiian nor my Caucasian roots, I have always struggled

with who I am who am I and where I come from. I've often wondered why we do the things that we do. I think this is true for children learning mathematics. "Why are we doing this? Why should we care? Who am I in relationship to this subject?" When children don't see the application of the mathematical concepts in their lives and in their environments, does the mathematics have any relevance? And if the mathematics is seen as something outside themselves, brought to them by others from the past or something that comes packaged in textbooks, then what implication does that have on what they think of their home cultures? They believe that their cultures were and are "mathless."

A sense of inferiority sets in. Consider you are a child. You go to this school and you sit in this room. Your teacher is trying to make you do things that are in this book. In this book are words you don't know and symbols you don't yet recognize. There are pictures of objects and situations you have not encountered such as horses and beavers, interstate highways and cities, frozen rivers and snow. Your teacher gives you a set of rules to follow using those rarely seen symbols to represent the unfamiliar objects and situations. You have no idea where these symbols came from or why they were chosen. You try to follow your teacher's rules, the ones written in English, partly in words and partly in numbers and symbols, in that book, trying with all of your might. Then you get tested. You don't do well.

First, because the language that this book is written in is not yours (it is in English), you don't understand what is being said. In fact, your teacher (whose first language is probably also not English, nor is probably not an expert in mathematics) does not understand everything in it either. Second, you look at the pictures and you have

never seen anything in your life that looks like that. Third, the symbols in the book are a representation of mathematical thought that somebody came up with a few hundred, maybe thousands of years ago, somewhere very far away. And then school is over for the day and you leave. You forget everything that was in that book, those rules that you were told to follow, because, honestly, it was boring and you didn't understand what you were doing or why you were doing it. But wait, you have to do your homework. So, you take out that book try to remember the rules your teacher gave you to follow. You might be remembering the steps correctly, but can't be sure. Circle your answers! Always label. And, circle your answers! Oh! Forget it! Instead, I'm going to help my family do what needs to get done. My family needs me more than we need math. We never had math here anyway.

"I saw cars [for the first time]. Classmates told me that they were large land crabs used as pets."

Here is a story from a participant who grew up on Lamotrek, one of the outer islands of Yap. It is illustrative of how life for a child living on a Pacific island might be different than the life you know.

> My island is remote. We do not have running water and electric power. We only have one elementary school on the island. When I completed elementary school, it was time to go to another island where we have the high school for all the outer islands of Yap.

A cargo ship that came to Lamotrek approximately every three to six months arrived to pick up and transport the students.

> On our arrival morning, I was standing on the lower deck of the ship looking toward the shore; I saw the cars coming back and forth to the beach to pick up people and stuff. I wondered what they were. Classmates told me that they were large land crabs that were used as pets. I wondered how good it would be to have one of those obedient crabs.

The participant also shared that while on shore, it was even more surprising that water would come out and lights would turn on by just touching something. Imagine being an elementary school student on Lamotrek, trying to learn the mathematics in a textbook.

As part of the goals of MACIMISE, we were trying to focus on how culture could be used in relation to teaching mathematics. By engaging students in cultural practices, those that they would encounter in their everyday life, we were trying to bring some relevance to the mathematics. Whether the children would be engaged in ethnomathematics or not, the hope was that they would be connecting some cultural experiences or some aspect of their local culture with mathematics.

"It was also the first time I thought I was dumb."

Part of what MACIMISE allowed us to do was reflect on what we experienced as students. Time and time again, instances of our relationship and experiences with language and culture surfaced as an integral part of how we shaped parts of our personal identity. One participant told a story about how as a student, the aspects of language and culture affected aspects of self-esteem.

> I am a Chuukese was born, raised on the island of Saipan…In second grade my teacher was Filipino and had a thick accent that made it difficult to understand

> what she was saying. I remember that we had just started learning subtraction. I did not understand her instructions to an assignment she had put on the board and so I added all the numbers together and turned in the assignment. She immediately marked a big "X" on each problem and threw the paper back at me saying, "Ay this Chuukese! It's subtraction not addition. Don't you understand?" It was the first time I was made to feel that being Chuukese meant being less in some way. It was also the first time I thought I was dumb.

As adults, people can usually separate what is said to them from who they are. But children are different. They believe what people say to them. It shapes their identity, their sense of self. Their boundaries are not established. Instead of "I know who I am and where I come from," it is "I am who you tell me I am" and "tell me about where I come from" and "I will believe you." This can be dangerous territory when mathematics is perceived to be a subject outside oneself, something one does not have, and yet so very important.

First, it is comprised of definitions and procedures that work sometimes, but change depending on what you are considering. How many children have been ruined mathematically because they "just don't get" the complexity inherent in the following rules:

- When you multiply two numbers, the answer is bigger.
- But now when you are multiplying decimals, the answer gets smaller.
- When you are multiplying a whole number by a fraction, the answer is bigger.

- But when you are multiplying a fraction by a fraction, the answer is smaller.
- In this fraction, the number on top is the number shaded in and the number on the bottom is the number in all.
- But in this fraction, the top number is the number of these and the bottom number is the number of these. It's a part-to-part ratio.

What's bigger? And what's smaller? And what are these and what are those? But most of all, who cares? Why should anyone care? For children who are not as affected by negative comments told to them, supported somewhat by their families and told that education does matter, we work hard to understand. And whether or not we understand, we work hard to pass, just as the participant in the previous page continued to explain.

> I excelled not because my mathematics skills were impeccable, but because I had a genius for a tutor who somehow found ways to help me understand enough to complete my assignments and do well on quizzes and exams. I took pre-algebra as a freshman, geometry as a sophomore, trigonometry as a junior, applied mathematics as a senior, and pre-calculus as a senior elective. Looking back, my mathematical understanding and skills only scratched the surface. I was determined to pass my courses, but not to truly understand. As soon as I passed these courses, I immediately forgot what I learned.

For the mathematicians who understand and appreciate mathematics and for the critics who say ethnomathematics does not exist, this sounds like an excuse. But for the millions of us who understand mathematics to only some degree and have never been

exposed to ethnomathematics, does this sound familiar? How many of us have been determined to pass our courses, but did not understand, only to forget as soon as the test was over? And what about those students who did not understand at all? Honestly, we don't care. Why should we? It just makes us feel bad about ourselves.

"My passion for mathematics started…when I had…teachers who spoke the same language as mine."

When participants wrote and shared about their personal histories in mathematics education, many told about how language affected their experiences. A participant from Pohnpei explained.

> My passion for mathematics started in grade school when I had Pohnpeian teachers who spoke the same language as mine. I didn't have a hard time understanding them…Later in high school, I found teachers knew the subject but had difficulty teaching it. The higher-level courses were offered by non-native teachers because few locals were qualified and comfortable teaching these courses…The challenges I experienced as an English language learner persuaded me to focus on mathematics teaching.

Another participant from Samoa shared that most of the mathematics personally learned in early schooling was through "problem solving in my native language" and working with the individual's grandfather who had a passion for teaching mathematics.

> I would take the math problems that we discussed in school and try it at home with my grandfather, who was not fluent in English…I would try and translate the

> problem into my first language before attempting to solve it, a strategy I learned from our discussions at home.

Later, when becoming a teacher, this same participant continued, “I found that teaching math to my Samoan students required the translation of English word problems to Samoan in order for the students to solve the problems.” This became true for both the elementary school students and college students this participant taught.

Others shared similar language issues. “Working with word problems is probably the most difficult task I had to face in learning mathematics.” MACIMISErs shared that they skipped word problems or had to translate them into the local language so that their students could engage in them. They also shared that they had teachers who skipped word problems altogether. “It is not unusual for us to focus on computation skills for most the school year.”

By ignoring or subjugating one’s home language to English, what I believe is the dominant mathematical language, I argue that children are being robbed of their ability to experience mathematics that makes sense. They are unable to use language that makes sense to them, nor in contexts they understand while their existing cognitive and cultural strengths are often ignored.

CHAPTER 7

OUTSIDERS LOOKING IN AND INSIDERS LOOKING OUT

"Much more extensive research is needed."

In the act of trying to accomplish MACIMISE's first two goals—examining local cultural practices to rediscover and/or uncover indigenous mathematics through working with elders or other experts in communities; developing, leading the implementation of, assessing and refining mathematics curriculum units based on these culturally practices for grade one, four and seven students—a theme that surfaced strongly was what I call "outsiders looking in and insiders looking out."

In January 2010 we were more than thirty participants vying for the twenty or so available spaces in the project. We were taking EDCS 606, Introduction to Research in Curriculum and Teaching utilizing Blackboard Collaborate, the on-line virtual classroom platform. The syllabus stated that we were to "produce a research paper that carefully described one topic of indigenous mathematical knowledge or practice in our own culture." These research papers were to provide the information necessary to later develop the mathematics curriculum units.

For that class I chose to investigate the ipu, Hawaiian gourd, hoping to answer some questions: What mathematical thinking did Hawaiians employ during cultivation, in working with the fruit to create various containers, in fashioning kōkō, or nets, for carrying ipu, and in creating the geometric designs for ipu pāwehe, gourds decorated with designs? I met with Valentine Ching, Jr., a Native Hawaiian craftsman in Hawai‘i who had, through years of experimentation, relearned the lost art of making kōkō. One thing I

discovered is that it would require an apprenticeship with this craftsman to even begin to comprehend the mathematical thinking he might have engaged in. There was no way I could understand what mathematical ways of thinking an ancient Hawaiian might have employed in creating these objects without becoming a practitioner myself.

Therefore, rather than considering the making of kōkō, I shifted my focus to the geometry I saw represented in completed kōkō and related designs on ipu pāwehe. I found that I was subjecting these artifacts to my personal analysis, the critical eye of an observer from another time. How much authentic culture and history was actually being recognized and represented by doing this? I was slightly disturbed because for the purpose of designing a curriculum for today's students, it is necessary to examine this ancient craft using modern frames and language. I created categories and distinctions around the designs through a modern, Western lens. And these categories themselves were probably flawed. In the course of my research I came upon this passage by Stokes (1906), an American photographer, genealogist and archaeologist at the Bishop Museum in Hawai‘i between 1899 and the mid-1920s, who wrote about Westerners trying to categorize artifacts.

> There are many attractive patterns in the kōkō pu‘upu‘u, to which no native in these days is able to attach any significance or name. One old native, after being questioned in vain, remarked disgustedly: "The haole (foreigners) want all the time to put a number or a name on everything, but these to the natives were just kōkō." (p. 57)

I felt guilty of the same: seeking to name and categorize the mathematical objects I saw through my Western eyes with terms drawn from Western geometry: quadrilateral, pentagonal, rotationally symmetrical. In so doing I could easily translate these objects into formal academic mathematical content and processes appropriate for mathematics curricula. But by itself I was feeling that this was incomplete.

The first goal of the MACIMISE project—of rediscovering and/or uncovering indigenous mathematics—was proving difficult. Indeed, Ching had worked for about seven years to perfect the lashes and hitches of one particular kind of kōkō. This was time I did not have. Furthermore Ching had reverse engineered the methods of plaiting fibers to make the kōkō by looking at ancient artifacts in museums and books. There's no way to be sure, therefore, that the type of mathematical thinking he engaged in was at all similar to what ancient people were doing when they created the originals. The question of what may be considered authentically "indigenous" became, in this situation, unanswerable.

Three other MACIMISE participants wrote that, for the purpose of creating mathematics curricula, the information they collected was sufficient. However the majority of the participants concluded, like me, that they may have been missing aspects of the cultural practice. Several of us documented the need for additional research into indigenous or local practices. Many participants reported facing the challenges of insufficient time, limited opportunities to meet with elders and experts and the lack of uniformity of the information they received from them.

One participant discussed a need for more direct engagement in the process to fully understand it.

> I needed to learn and understand the process of making siapo [Samoan bark cloth] and its historical context first. Questions about the mathematics in siapo did not occur until I was better familiar with the siapo process, but even now as I write I am formulating more questions that I wish I had time to ask.

Part of this participant's discovery was that "A wider collection of siapo samples need to be analyzed with a more critical mathematical lens. I also feel that more siapo makers should be interviewed, observed and recorded to get a deeper understanding of how they use mathematics." In addition to working with cultural practitioners, "work needs to be done on exploring the history, the tools, different artist styles." This MACIMISEr concluded. "The application of mathematics in siapo making is much broader that I originally thought. Much more needs to be documented for future generations before the art and mathematics behind the art is lost forever."

Several participants researched aspects of counting and measurement found in their cultures. They found that counting and measurement systems were very complex and varied depending on specific cultural activities and the locations where they took place. They also felt limited by the lack of existing information. A participant from Yap wrote about how "There is incomplete and outdated information available today" regarding counting systems. "Much more extensive research and effort is needed to document a more or less comprehensive counting system for all the outer islands." In addition, "More research is needed to improve and expand the documentation of the

measuring systems" as well as the "traditional knowledge and skills in the area of traditional building [and] navigation…to preserve the knowledge and skills and to pass on the information to the next generations."

Why study indigenous mathematical ways of knowing?

Indigenous knowledge, according to Grenier (1996) "refers to the unique, traditional, local knowledge existing within and developed around the specific conditions of women and men indigenous to a particular geographic area" (p. 1). Indigenous knowledge systems are cumulative and dynamic in that they are the result of generations of experiences, change as a result of internal innovation and are influenced by knowledge brought by outsiders. Many participants lamented the fact that their islands' indigenous knowledge was disappearing, being replaced with outside knowledge predicated on the foreign value of monetary wealth. In the past, indigenous knowledge systems had been the result of people finding ways to survive in their local environments. In the present, dominant knowledge systems support what is perceived to be college and career readiness, placing importance not on sustainable practice and education for the survival of all cultures, but education whose purpose is to prepare citizens to get jobs, part of the dominant socio-economic-political paradigm.

Dominant academic content, much of it utilizing English as its language, is taking over. I argue that it includes the mathematics that is not the mathematics that allowed people to survive and thrive in their natural local environment in sustainable ways for thousands of years. Instead, at its least destructive, it is the mathematics required to do well on a formal written assessment. This is the mathematics that says it is important to

perform the standardized algorithm for double-digit addition and subtraction and use a bar diagram to solve one-step word problems. Most destructively, it is the mathematics that has made unsustainable growth possible on our planet in just the three centuries, causing what will be the literal submergence, as sea levels rise, of many of these local environments, along with their indigenous knowledge systems. I am not negating the positive aspects that the dominant form of mathematics has made possible, including those that have brought about modern technology. However, with a Eurocentric view of mathematical history, the mathematical contributions of many other geographical areas have been neglected or omitted (Powell & Frankenstein, 1997).

Barton (2008), for example, discusses how Pacific navigators are able to feel the swells coming several different directions simultaneously and cites Kyselka, 1987, as saying "the most contemporary navigator Mau could detect five." (p. 102) Mainstream mathematicians:

> can generalise from the one-dimensional problem to that of waves coming from several directions…The problem of two waves coming at right angles to each other can be solved computationally…But the problem has not been solved for waves coming from four different directions, and no instruments have been developed that will quickly resolve a wave movement into four directional components. (p. 102)

Barton continues to consider what might have been possible.

> Imagine that all (even a good fraction of) that money and effort had been put into analysis of wave motion and developing technology to sense swells in the

> ocean…ships would now be equipped with such sensors, and would have computer systems that could resolve the information and detect changes in the size and directions of the swells under their hulls

had "all of the mathematical and technological effort that went into the development of [Pacific] navigation" (p. 102) been paid attention to by those that choose what mathematics and technology is important.

> This story of unrealised mathematical development…illustrates what might have happened if mathematicians had become interested in the systems of Pacific navigators. We can imagine that harmonic analysis would be much further advanced than it is. This is what happens. Mathematics absorbs good ideas, techniques, even symbol systems, and makes them part of the mainstream of the subject. The worth of the ideas are judged on mathematical grounds. (Barton, 2008, p. 103)

What else is "unrealised" because it has been subjugated, ignored, displaced or replaced? What is judged as worthwhile mathematics and who does the judging? The concerted effort to preserve what is left of indigenous knowledge systems may be a first step to correct some of the negative colonizing aspects of Western education in the Pacific. If we ever find ourselves walking again to get to most places on our own two feet, having to carry water containers as we journey, being able to fashion cord and kōkō will be valued knowledge.

One participant shared about the choice of situating the mathematics curriculum unit in local house construction. There was not only the potential to extract mathematics

from the practice, but also, the MACMISEr described that the skill of house construction was "fading away" from the young generation. The participant's hope was to "raise interest in the school children to continue learning the practice of local house building." With less outside funding, "it is very difficult to build and maintain these Western-type houses. We need houses that we locally build with local resources and skills." Being in a region prone to bad weather and frequent storms, local style houses are must faster to build and "all of the resources are immediately available in the environment." When outside materials are required to build Western-style houses, sometimes years go by before a house is constructed, the participant continued, because of "the shortage of funding and/or materials to construct them."

If, and I argue rather when, we find that cheap oil is no longer available, making air travel impossible, the mathematics inherent in Pacific navigation will be considered "worthwhile" by those that make the judgments about what mathematics is "good." Local houses and local house building will be valued. Using the standardized algorithm and lattice method for double-digit multiplication may not be worth much. Let us do the research and give attention to that which has been forgotten or pushed aside. It is needed so that we do not forget nor lose the knowledges that might make new and better technologies and even new and better realities possible. Once again, we indigenous might have the right to be insiders in our own culture—to know, understand and use our own skills.

"Do we actually see the mathematics?"

In summer 2011 we met as a large MACIMISE group in Pohnpei that included all

of the participants, the project leaders and various consultants from different universities. We met in consultation groups, each comprising one or two advisory board members, three course instructors, two co-principal investigators, two or three masters students and two or three doctoral students. One participant tried to summarize what we had been prompted to discuss by a consultant during a circle at the end of the day: “I think what we were trying to do [was to determine which was] more appropriate: teaching mathematics through our culture or using the culture to teach mathematics.” At the time I did not fully grasp the subtle differences between those two things. They do, however, concisely summarize one of the major challenges facing a project like MACIMISE. They reflect what we as participants have and continue to grapple with.

One possible interpretation is that in “teaching mathematics through culture,” the culture is the priority. If one is a cultural insider who authentically participates in cultural activities, mathematical thinking and objects arise naturally. The insider passes on the knowledge of the cultural practice to others within the culture who are to learn it, and therefore the inherent ethnomathematics is implicitly also passed on. The need to name mathematical ideas and objects or explicitly describe processes might or might not arise. The outsider, on the other hand, might “use the culture to teach mathematics.” There is a presupposition that there are mathematical ideas, independent from the cultural practice, which must be taught. The outsider will look for these preconceived objects, as I looked for rhombi and rotational symmetry while examining kōkō. The task then is to identify elements of the cultural practice that match these preconceived ideas of what mathematics is. The aspects of the cultural practice that do not represent such ideas are

marginalized if they are recognized at all.

It is not hard to predict the difficulty the outsiders might have in trying to understand a cultural practice foreign to them, but what about the challenge facing the insider who must use their own culture to teach a concept foreign to it? Many MACIMISE participants, myself included, live in our communities but do not practice the native culture; we are outsiders. Others are experts in their local communities, very much insiders. One such insider, a participant who is also a local community leader, reflected after a consultant group meeting:

> I tried to differentiate my culture and the way I teach. It's very hard. As part of the MACIMISE program, the goal is to use the cultural practice to teach the mathematics. And I ask myself, so what is it to you then? To me, I'm involved. I'm part of the culture, I know the cultural practice, so I will observe and try to get as much math out of the cultural practice. And I go back to the classroom and convey to my students.

My interpretation of this is that this cultural insider is such a part of their culture that they may not be able to step outside of it to look at the greater context of the local culture in relation to the school culture. It is taken for granted that because this participant is an insider, there is no problem identifying the mathematics in a cultural practice and "conveying it to" the students. However, is this individual actually conveying the innate aspects of the cultural practice or are they mere personal perceptions regarding exogenous mathematical concepts? And how could or would one know?

And yet another point of difficulty is how to convey the information to students

who themselves might be insiders or outsiders, either of the culture or of the mathematics? The insider must learn to look out—of the local culture, the cultural practice, the dominant culture, the ethnomathematics, and the mathematics all while attempting to perceive what is happening from all of the positionings of the students—and then learn to look back in, continually engaging in this circular process as knowledge adapts along with those that then carry that new knowledge. This contrasts sharply with the direct teacher-to-student linear discourse that is prevalent in most classrooms, where the student is generally the outsider, told to absorb what is being presented to them, wholeheartedly and without question.

The MACIMISErs who were not cultural experts experienced a different struggle: to understand our own cultures and cultural activities. We were learning language we did not know and were being exposed to knowledge and skills that might not be passed down to us because of our gender, age, social status, and/or our roles and responsibilities in our homes and communities. Furthermore, almost all of us had been taught in schools modeled on mainland United States schools. When the outsiders observed cultural activities, they were able to identify Western concepts, but they reported difficulty going more deeply into the practice to understand "indigenous mathematics." One participant, who was educated in the West and later returned to live back home in the islands, reported some frustration with this challenge.

> When we observed the elders doing the activities we were able to identify the math in the cultural activities because of the background that we came from, the Western perspectives we're taught in the classroom. We're always outsiders

> looking in and trying to identify—OK, that's geometry, that's algebra in the cultural activities—but when will we be the ones inside looking out?

Another participant described feeling like an outsider looking in when interviewing a cultural expert creating bark cloth designs.

> While I was observing her, I was very naive and impatient. Was that measurement? How did you measure that? Is that the shape? What shape is that? Did you start in the middle? I was trying to figure out the mathematics. And I was trying to interpret it in my eyes.

When this observer made the shift to being a participant, however, something changed:

> And then finally I started to draw and create my own, and I saw it differently. And I realized that all the questions that I asked and the things that I thought were the mathematics were not necessarily the mathematics of the actual cultural activity once you were creating it. … And it wasn't until I actually did it. So are we looking in from the outside? Do we actually see the mathematics? Or is it once you actually do it that you realize what the mathematics is?

The question endures: How is it that we identify the mathematics? Is it from inside an activity, within its actions? Or is it a priori, derived from theoretical deduction, acultural?

"Do I think about it as a math teacher or do I think of it as a cultural teacher?"

In the summer of 2012 we met again as a large MACIMISE group in Palau. However, rather than grappling directly with these difficult issues, our task turned to

creating the lessons that would become our mathematics curriculum units for grades one, four and seven. One participant reflected on the process in a talk-story session in Palau in 2012. They "couldn't really see anything significant mathematically in our cultural events" and wondered, "will it even become really rich curriculum?" This participant had doubts about whether there was rich mathematics in their home culture.

> I had trouble seeing it. I had trouble visualizing what mathematics was there. Until we took that first course. Wow! There is! There's tons. But there was tons in just this one cultural practice. But what about others? So I still felt that there was still not that much rich mathematics, enough to make curriculum … And so if we could use ethnomath to teach math in Samoa it would be to teach only a few concepts. … And then my belief [that] there wasn't that much mathematics in our culture changed over time. And it was my experience through more activities and experience conversing with other people that made me see more.

This same participant reported having difficulty in writing lesson plans until teachers participated in the cultural activity alongside each other. Reflecting on the process of the teachers and personally trying to become an insider by practicing a cultural activity: making a hand broom, the participant shared:

> I just asked one question: "How many coconut leaves does it take to make one [hand broom]? Teachers had to demonstrate it first. Don't answer the question. Demonstrate. And then think about the answer and come up with extension questions. More mathematics. You couldn't answer that question just by counting. You had all of these cultural things like maturity of leaves, thickness, preferences.

> Being involved in ethnomathematics really opened my eyes. [Before this] I only thought of a few things that we could do with the lessons, a few things that the teachers had to do with the lessons, a few things that the students had to do to show that they learned something. But now there's so many different things that I had to think about. In terms of what students say, what they do, what they write, what teachers say, what they do, their instructions, their cultural knowledge even. I didn't even think about that. The teachers need to have the cultural knowledge.

The realization this participant had about the need for everyone participating (teachers and learners) to be insiders in the cultural activity in order to authentically participate, to experience the ethnomathematics, was one that came up for me and also for others in different ways and in different contexts. A new realization immerged from this MACIMISEr.

> You have to do the cultural practice to really see mathematics. It was the stuff that was actually going on in the process of making and doing cultural activities. We couldn't create a unit plan with the cultural activity that we weren't recently engaged in.

By engaging in the cultural practice, the participant reported that there was the ability to see the mathematics. Further, the teachers involved were also able to see the mathematics. However, a difficulty was also shared.

> Sometimes we are writing [curriculum] as math teachers more than we are writing it as cultural teachers. My transition even now as I'm adjusting my unit plan is that I stop thinking about the math and think about the culture and what they

> would naturally do. And what's the math that happens there? So I'm always torn in between—do I think about it as a math teacher or do I think of it as a cultural teacher? That's the struggle I'm having now, but I'm getting there.

Working together as MACIMISErs, in teams of outsiders and insiders, collaborating and reflecting, allowed us to have experiences wherein we could explore both looking in and looking out. "I talk a lot with [my MACIMISE partner]," said one participant, "about teaching math and approaches and pedagogy and teaching the culture and being true to the culture that's there." Another participant shared about how they collaborated to create their units. As participants we were very different, some of us outsiders and others insiders, switching roles as the paths diverged. Still, our varying roles were mutually supportive.

> The counterparts in my group come in with some knowledge. They are not masters, but they were around when their uncles and grandfathers used to build houses. They know the vocabulary. They know the history. They know the symbolism of things. I don't. I was born and raised somewhere else. I have that disadvantage. Every day when I'm talking with them, it's a learning experience. And humbling. It's brought me closer to who I am.

This individual shared about how these experiences with others allowed the opportunity to look into the home culture in new ways, but also allowed others to look at their culture from outsiders' perspectives. They simultaneously examined the aspects of the cultural practice from an insider's perspective to attempt to reconcile it with an outsider's perspective and vice versa.

> I think it's good for them, too, because I ask a lot of questions: Why do you call it that? Why do you use that kind of measurement? What's the whole importance of the [part of the house] that has no function? …That is frustrating because I don't know a lot of things and I don't know when I'll use it. I'm not going to go home and say, "Dad, I want to build a traditional house" because that is not my place. Even with all of the specialists, the master builders we've been interview[ing], I think the important thing to stress is that I always feel like an outsider [always asking] "what does that mean?"

"I'm a math teacher. I can see the math in there." versus "I've never taught."

I taught elementary school for ten years, have taught people to teach mathematics and have acted as a consultant in elementary mathematics for the last seven years. This makes me an insider of elementary education and curriculum writing. For those that have taught in middle or high school exclusively, they are outsiders to writing elementary level curricula. Other MACIMISErs had not taught at all. This sense of otherness is a challenge especially for these participants, particularly when trying to fit their native culture into a form accepted by Western academia.

> I'm struggling with coming up with my units because I am not familiar with curriculum writing, especially a unit. I don't know how I can put my lessons together into a series, a sequence that's related. Especially because you are dealing with cultural concepts [and having to] put it in a Western format. I chose a

> grade one unit on counting and measurement. It's been challenging because I've never taught elementary and first graders so I don't know what to choose.

It takes a special kind of knowledge and a wealth of teaching experiences to understand the complexities of teaching first graders mathematics as well as being able to perceive the world through a six-year-old's eyes. Just as it takes a special kind of knowledge to participate in and share about cultural practices. I believe that these can be inclusive, but for many it was difficult at times to see through any lenses other than their own, to move beyond their own experiences to be able to create curricula that focused on both formal curricula writing and their cultural practices.

A few participants discussed how, because they had only experienced education modeled on traditional American pedagogy, a challenge was to think dissimilarly to how they previously had. Another way many of us were outsiders was that we, ourselves, did not experience classroom instruction as elementary, middle and high school students based in ethnomathematical ideas. One participant was trying to help colleagues design their lessons and was struggling with marrying those roles.

> The main difficulty is, they did not experience it when they were students. So, visualizing how to do it in the classroom is the difficult part. Because it's kind of easy as a mathematician to say, here is the cultural activity. I know this is the math in here. But the difficulty is to think about the pedagogy of it and visualize how it will be done in the classroom…I'm a math teacher. I can see the math in there. I can see the activity…But I have difficulty figuring out how it [the cultural activity] would be done in the classroom.

This fusing of cultural practices, beliefs and values were sometimes at odds with our goals of creating curricula based on Western standards. We were constantly grappling with a question proposed by one consultant in July of 2011.

> In any cultural practice, how is it that we are identifying what we're calling the mathematics? Is it because it related to something we know, from say school mathematics, or is it something else? And so the questions of how do we identify the mathematics of the cultural practice is what I'm leaving with here.

And so my continuous struggle, and I think what others were also struggling with even if not consciously, was partly: when we only know "school mathematics," can we identify anything else?

CHAPTER 8

CREATING AND PILOTING UNITS

Initial Grappling with what a "Unit" Is

In July 2011, we were struggling with what a "lesson" and "unit" could possibly look like. For those of us who were teachers, and who had experience with designing problem-based mathematics curricula for ourselves, we had what I perceived as an easier time envisioning the many possibilities of what our mathematics unit could look like. For example, one experienced teacher shared "A unit could be like 'area'…I think they are going to be units because I'm thinking about a series of things that build up the mathematics…but I don't know. I can't say how long I intend it to be." This participant was comfortable with that uncertainty.

I initially envisioned my unit as having first, fourth and seventh grades all working together for a semester or even a whole school year to complete a task, such as building a traditional house wherein "the math will come out as the structures are being built…[considering] what roles the first graders, the fourth graders and the seventh graders take in that construction." I was the only participant at this time to consider this integrated grade level curricula design. Another participant, also an insider to elementary education, shared that the unit could be "roughly about ten times, two hours each, twenty hours [total]. Could be longer or shorted, spread out, depending. … It could be less or more, depending. Teachers find that if it's too long, kids lose interest." So, for those of us who were teachers, the uncertainty of defining what a lesson and unit was a comfortable

place for us to sit. However, for many outsiders to curriculum development and implementation, it was difficult to envision what lessons and units might look like.

It is my interpretation that in an attempt to give participants a little more guidance and possibly to provide a bit more comfort for the non-educators, in Palau in the summer of 2012, project leaders provided a unit plan template (Appendix F). I also believe that there was a perception from some of the project leaders that the lesson and units should be more or less uniform, or have some consistency in format, for easier reporting and project evaluation. It was suggested that the units could be five lessons long, about one school week.

This became the general goal of most of the participants—to "fit" the content of the cultural activity and the mathematics into a unit that spanned about five days (or five lessons) using the given unit plan template. For those of us who were educators, we first struggled with trying to "fit" our lessons into the newly presented structure, although some of us ended up deviating from it. The quotes presented in this next section are from an individual interview I had with one experienced teacher in the summer of 2012 in Palau. The template ended up being experienced as a hindrance for many MACIMISErs.

> I was really struggling earlier. Our [consultation] group was coming together. There was so much discussion about the template. It came about where we were doing this whole group thing. Someone would present [their lessons] and then we would make some comments. One advisor said this, another said that, another advisor said something else…So we [the participants] all just sat back and listened to them talk to each other.

This participant "felt bad" for the first MACIMISEr who shared with the group. "He was in the *hot seat* and he had done all this work." The advisors shared concerns and asked questions, described here by this participant:

> What is your rationale? Can the kids really do this? Why don't they make a scale model instead of building the hut? Stuff like that. It was really major. At one point [the participant in the "hot seat"] asked, "do you want me to change it?" And we said, "oh no, we can't be doing that." And so the consensus was "stop right here." People can pair up and work one-on-one with an advisor. It would work better because…the guidance was more individualized and focused.

This consultations group's process seemed to alleviate some one of the issues that were arising; different project consultants had varying opinions, beliefs and values. That confused some participants because they were being given conflicting advice. There were the differing cultures and experiences of the individual consultants and the individual participants as well as the variables associated with the composition of each consultant group, and so on; this affected the goals, expectations and perceptions that people had. The same participant continued.

> Each of us had such a different context in our culture. The idea of maybe looking at the template first was not a good idea. Maybe we should look at the activities first. [Another participant] asked me, "I have to put my activities in the template? Well, I haven't talked to anybody about the activities yet. So why would I want to put them in a template? Then I will get advice that the activities aren't matching up with the mathematics. I would rather hash out the meat of the activities and

> then put those details in any template." But we know that because we are teachers. But for a lot of others, they are not comfortable with that [putting things in a template]. It becomes a huge hurdle: Wait a minute, I was just doing a cultural activity and pulling out the math and now I have to do *what*?

We were also receiving additional instructions from program evaluators; we were to consider our formative and summative assessments and plan for them in our lessons and units. I sat alone with a consultant to share some of my concerns with what I was hearing from participants. This particular consultant didn't understand why we were starting to plan assessment when we hadn't finished hashing out the details of the cultural activities the students would be engaging in. It was this consultant's opinion that we were being directed to pay attention to assessing the students prematurely.

In summary, we each came from different cultures. Each participant's culture and cultural activities varied greatly. There were the very unique personal and academic backgrounds of each participant as well. And in addition, there were the many consultants, advisors and program evaluators, all from different cultures. They each had their own beliefs and values informed by their personal cultures and experiences as well as their differing academic backgrounds and expertise areas. Finally, because MACIMISE was NSF funded, we were all subjected to NSF's expectations. This all became part of the culture of MACIMISE. We were all, as you the reader are now, outsiders looking in and insiders looking out.

My Unit

Indigenous vs. Local

One of the requirements of MACIMISE was that participants develop mathematics curricular units for grades one, four and seven that were sensitive to "local mathematical thought and experience." In considering ideas for my unit, I struggled with the question of what "local mathematical thought and experience" in Hawai‘i was. The idea, as I understood it, was to find some sort of mathematical thought or practice that was endemic to the native culture of the Island; in the same way that hula is a native dance or lua is a native martial art, I intended to find some sort of mathematical practice that was inherently "native Hawaiian." [Note: throughout this chapter, I use the terms "native" and indigenous" interchangeably.] But my experience proved similar to that of another participant, who "had difficulty in the very beginning just with the definition of ethnomathematics because our island is very Western. So even though we have indigenous practices, they are not what our people do today."

The culture of O‘ahu, where I live, is multiethnic, multilingual and like the rest of the United States steeped in consumerism. While there are remnants of indigenous culture throughout the state, Hawai‘i's culture is very different from the culture most people probably imagine when they think of native Hawaiian culture or indigenous Pacific Island cultures in general. A person could spend his or her entire life in Hawai‘i and never meet a native Hawaiian or participate in an activity that one might consider indigenous to Hawai‘i.

Within the Hawaiian Islands, language is carefully applied to make important cultural distinctions: A “native” is someone who is of native Hawaiian racial ancestry. A “local” is someone who has grown up in Hawai‘i, whose family may even have been here for generations but who isn’t of Hawaiian descent. Very often “locals” engage in indigenous practices—like dancing hula or learning ‘ōlelo Hawai‘i (Hawaiian language), but care is still taken to maintain the distinction between a “local” and “native.” The lines, of course, have been blurred by two hundred years of assimilation and absorption; there are very few people left who can claim 100 percent native Hawaiian ancestry. It’s safe to say that the native culture of Hawai‘i is less intact than that of the much smaller island groups participating in MACIMISE. So I was faced with a problem: I needed to create a unit that would be relevant to most of the children in a “local” classroom but that also expressed some form of “native” or “indigenous” Polynesian mathematical thought and experience.

In the beginning of the MACIMISE project, I had hoped to engage in an indigenous practice so that I could extract mathematical ways of knowing and being, ways that might be different from the mathematics in which I had engaged during my academic and everyday life. I quickly realized that in order to fully understand an indigenous practice, I would need to engage in it over time. Apart from learning rudimentary hula and strumming a few chords on the ‘ukulele, there were no indigenous practices with which I had any direct or prolonged experience. And the circumstances of my life—busy with work and family—did not allow me the luxury to become a true practitioner with authentic knowledge and skill. Other participants also struggled to

"juggle my work time, family time, with MACIMISE work" as well to communicate with other MACIMISE partners in different locations and time zones to collaborate on designing and piloting their units.

I decided that I would teach in summer school in 2013 where I would have freedom from expectations associated with standards and test taking and wouldn't be restricted by the same timetables and benchmark maps of the regular academic school year. And, rather than designing a unit that was based in an indigenous practice, my plan was to have the students to bring their own cultural artifacts and experiences in to class; we would attempt to discover the mathematics in them. That way, we could honor the students' varied cultures while also showing the students that mathematical thought—whatever it turned out to be—could be found in any human endeavor. We might discover some of the ethnomathematics in their culture and cultural artifact or activity, or we might use school mathematics in our interaction with the cultural activity or artifact each student brought.

From Unit Plan to Classroom

That intention was never realized because in spring 2013 another opportunity presented itself. A fourth grade teacher who was hoping to finish a masters degree approached my advisor, who described the unit I hoped to implement as part of MACIMISE. It so happened that we had taught in the same school when I was an elementary school teacher. We had a good relationship and respected each other highly. I called to explain that I needed to design and implement a unit based in ethnomathematics; I wasn't sure what it would look like, I said, but that I would love to do it there. The

teacher was enthusiastic. I would bring my unit to that classroom in the fall 2013, and whatever research we did together could be mutually beneficial. It would support me in project MACIMISE while also supporting my colleague and friend toward completing the masters degree.

At about the same time, in April 2013, the Polynesian Voyaging Society (PVS) gave a presentation at the UHM College of Education about two kalau wa‘a (Polynesian voyaging canoes), *Hōkūle‘a* and *Hikianalia*, that were preparing to circumnavigate the globe beginning in 2014. It is an immensely ambitious project, something never before undertaken. “The mission of *Hōkūle‘a*’s Worldwide Voyage,” as stated in PVS’s web site, “is to navigate toward a healthy and sustainable future for ourselves, our home—the Hawaiian Islands—and our Island Earth, through voyaging and new ways of learning. Our core message is to mālama (care for) Island Earth—our natural environment, children and all humankind.” Soon after viewing a recording of the presentation about the Worldwide Voyage (WWV), I read *Hawaiki Rising: Hōkūle‘a, Nainoa Thompson, and the Hawaiian Renaissance* and had lunch with the author, Sam Low.

The WWV seemed to be the perfect context for a culturally relevant mathematics unit, one that also might appeal to the “local” sensibility because voyaging had been well publicized throughout the Islands and at least some students would be familiar with the Polynesian voyages of discovery if not with *Hōkūle‘a* itself. It drew upon the recently revived Polynesian arts of wayfinding and stellar navigation to link places and cultures from around the globe. It demonstrated how ancient knowledge and skills could be used

to work toward a more positive future. Voyaging is an ancient practice that remains relevant today. After its rebirth in Hawai‘i, it spread across the Pacific and navigators would soon traverse the globe, connecting cultures. I believed that it was the perfect context for a fourth grade mathematics unit in a classroom comprised of students of many ethnic backgrounds.

The teacher with whom I intended to pilot the unit agreed that the topic was a good one; then we had to get it into the classroom. That seems like it should be the simpler part of the equation, but it was not. Doing research of any kind in the Hawai‘i State Department of Education (HIDOE) had become extremely difficult, often impossible. Approval for research studies had in some cases been withheld for months, even years. In the face of that bureaucratic hurdle, my personal relationships and connections became crucial.

Several MACIMISE participants similarly remarked that a personal connection was critical to their ability to implement their units—that they had to rely on their relationships with a teacher or administrator. One participant reported that one logistical difficulty was “trying to select teachers who can implement these lessons. … They just teach from the book, so giving them something like this would probably be a ‘no-no’ to them. They’ll just refuse.” This participant hoped that relationships with more “open-minded” teachers involved in the local teacher education program would help.

Participants who were classroom teachers had fewer obstacles; they could pilot the lessons in their own classes, and those who were teacher trainers or administrators could rely on employees, friends or relatives who were teachers to pilot lessons. How the

institutional and structural obstacles to piloting experimental curricula might be overcome is beyond the scope of this study, but it is a serious consideration for instructors hoping to implement culturally sensitive or ethnomathematics lessons.

In planning the unit itself, I had to take a few things into consideration. I wanted the context to be interesting and inspiring so that it would engage a diverse classroom population. I also needed the various constituents—teachers, administrators, parents—to consider the mathematics the students would be engaging in as "important" so that they would value the time spent on it.

I contacted the vice principal at the elementary school where the teacher with whom I hoped to partner worked. The vice principal and I had also taught together; we had worked closely on the same grade level as well as on university and professional development projects. Coincidentally, one of the school's foci for that year was to engage students in inquiry. The vice principal knew that one of my strengths was doing just that through project and inquiry-based instruction. I also hoped to make the content attractive to the broader administration by incorporating the Common Core State Standards for Mathematics and Mathematics Practices.

In June 2013 I received IRB approval for the study "Finding Our Way: Designing, Implementing and Assessing a Culturally Relevant Unit Engaging 4th Grade Students in Inquiry and the Common Core Standards for Mathematical Practice" (Appendix G). I received verbal permission from the vice principal and principal to work in the classroom with the condition that no student data would collected or shared (which is why much of my language throughout this chapter seems painfully circumspect).

I spent the summer preparing for the unit. I read a number of books about *Hōkūleʻa*, Polynesian voyaging in general and curricula that had previously been developed around it. The co-teacher and I attended a workshop at the Marine Education Training Center in May 2013, where we learned about navigation and met other educators working to build learning journeys around the kalau waʻa and their crews. Still, I was not a navigator; I had not sailed on a canoe. I had never even paddled a canoe. As much as I learned about voyaging, it was not practical knowledge and in no way could I claim to be a practitioner. During that workshop, an experienced navigator discussed how he navigated. While sharing about how he used the stars, currents and winds, he also remarked that one should not talk about living on a canoe if they have never paddled in one. This went back to my initial problem. If I were not a practitioner, I could never really know the practice.

I am a teacher, however, so I can teach. I know how children learn, and I can get them to participate in mathematical activity. I felt comfortable in that role and in facilitating the students in a fourth grade class to engage in inquiry and mathematical processes and practices using a cultural context. Still, I was aware that what we intended to do couldn't properly be considered ethnomathematics from a cultural standpoint. I'm not even convinced that it would be considered culturally relevant pedagogy, given that so few of the students had much if any prior knowledge of kalau waʻa, or even of Hawaiian culture in general. But I believed that an inquiry and problem-based mathematics unit set in the context of Pacific voyaging could be successful. Even better,

it would highlight the relevance of traditional knowledge in modern society and how it could promote peace and sustainability.

Implementing the Unit

While in Palau n the summer of 2012, MACIMISErs had been given a template (Appendix F) to use when writing and formatting the units. The template guided participants to design units that were one week (five school days) long. I knew, though, that I could not fit an inquiry and project-based unit into one week. To be successful, I knew from experience, I would first need to create a classroom community capable of asking good questions and using various mathematical processes and practices to answer them. Creating such a classroom culture takes time. I wasn't the only one facing this challenge; other MACIMISE participants also said that five days would be insufficient to implement the activities. "[The students] were not able to finish because it would take another one or two weeks," remarked one participant. "We don't schedule things when we do the activity," said another. "We just do it, and it happens as it happens."

Over twenty-four days between August 26 to December 16, 2013, I facilitated lessons in the fourth grade inclusion class with the two co-teachers, one general education and one special education teacher. There were between one and three teaching sessions per week, most lasting sixty to ninety minutes. When school was back in session in January, I returned for a further four consecutive days, January 7 through 10. Outside of class time the general teacher and I met regularly and in the last few weeks, every day that I was in the class and a few times other than that. The three of us also met outside twice in evenings for approximately three hours each time, once halfway through the

project and once at the end. The specific lesson plans we implemented and the teaching strategies we developed will be included in a paper titled “Finding Our Way: Designing, Implementing and Assessing a Culturally Relevant Unit Engaging 4th Grade Students in Inquiry and the Common Core Standards for Mathematical Practice” which will be written in the next year.

Ultimately our effort to create an elementary mathematics unit sensitive to “local mathematical thought and experience” was not, from a cultural standpoint, successful. Our attempt to create an inquiry and project-based unit was also, unfortunately, unsuccessful. Reflecting on the reasons for these failures will hopefully provide a useful foundation on which to build future, more successful mathematics units that are sensitive to local mathematical thought and experience.

First, as the teacher facilitating the lessons, I needed to be more knowledgeable about the cultural activity in order to create authentic experiences steeped in it. I know enough about mathematics and mathematics pedagogy to teach children, but I did and do not personally know enough about voyaging and navigation to “discover” the mathematics in it. Other MACIMISErs had the good fortune to draw on their relationships and invite elders and experts from their communities into the classrooms; in some cases their own family members were the experts. Although I reached out to the PVS to invite experts into the classroom, I received no response.

Second, although the classroom teachers had tried to provide the students some cultural background by showing videos from the PVS’ web site, for example, there was

not enough consistency. The students were not equipped with sufficient background to grasp the cultural and historical significance of the subject.

Third, coming into a classroom initially just one to three times per a week did not provide the continuity I needed to get to know the students and what I could expect from them. It wasn't until the last few weeks in the classroom that I finally formed the relationships requisite to getting them to actively and meaningfully engage. And it wasn't until then that the other teachers began to see what prerequisite skills and content knowledge students were missing to be able to participate in actively and meaningfully in the tasks activities I was bringing into the classroom.

Fourth, there was a disconnect between the type of instructional activities I brought to the classroom and the instruction students usually received. Textbooks and teacher-led instruction were the norm, and procedural steps were taught in a general absence of their conceptual underpinnings. I, on the other hand, was bringing in novel problems and high-cognitive demand tasks that students had to model meaningfully through the use of multiple representations. The administration required instruction to follow the text rather than accommodate the students' varying developmental levels and conceptual understandings. Thus teachers defaulted to rote teaching rather than working to create lasting relational understanding.

Although I am prevented from providing specific data regarding the students, there were some general issues in the class, which are representative of many classrooms in Hawai‘i that I can discuss. Class sizes are large. As classrooms have become more inclusive, there are more students—and more academic, social and emotional diversity.

This class was fully inclusive with the special education students present for the entire school day. My general education co-teacher reflected about how that this can be very helpful for the struggling learners, but that the accelerated learners become disadvantaged because they are given the least attention. Some students may struggle with counting and understanding the meaning of two- and three-digit numbers. Some students may have severe emotional and familial issues that affect their ability to communicate and participate effectively in classroom activities. Some students struggle with several different issues at the same time. Often, those may be the same students.

Even though there was the three of us teaching in the classroom together, it didn't overcome some problems. For example, if one teacher is managing the severely disruptive behaviors of just one student, it leaves the other teacher to deal with the range of learners of the other twenty-plus students. Even when students are put into small groups of just five to nine, the range of needs might still be so broad that tasks must be open-ended enough to be naturally differentiated. To have any success in such an environment, teachers must have deep and connected mathematical conceptual and procedural understandings. This takes much time and effort consistently over many years to develop. Because elementary teachers are expected to teach all content areas, I propose that there can often be only surface-level understanding of one or more content areas—and often one of those areas is mathematics. Even when tasks and problems are well designed, with multiple entry and exit points naturally differentiating them, severe student behaviors can still limit the ability of one or more students to actively participate.

While I cannot say that we met our original goals, there were some successes. By engaging students in mathematical tasks that required meaning-making rather than textbook-led exercises, teachers were given opportunities to listen to and observe the students' mathematical thinking. By paying careful attention to what students were doing and saying while engaged in problem-based mathematical tasks (that were or were not related to the WWV), teachers became better informed regarding what school mathematics concepts, skills and knowledge their students actually possessed. Because of this, we designed more appropriate problems, tasks and activities that better met the developmental needs of individual and small groups of students. By trying out various flexible groupings, we were able to provide varied tasks focused on developmentally appropriate concepts for the diverse learners in the classroom. It appeared that the students became better at self-monitoring, participating more actively and solving novel problems through engagement in appropriate physical and written models. More appropriate and effective mathematical discourse and modeling between the students and among the teachers and students seemed to result. Whether any of these successes can be ascribed to the cultural-based nature of some of the lessons is a question worthy of further study, but beyond the scope of this study.

Other MACIMISErs' Units

Contexts for other MACIMISErs' Units

As part of the goals of MACIMISE, we wanted to engage students in cultural practices, those that they would encounter in their everyday life to try to bring some relevance to the mathematics. A participant shared the plan for doing this. In Palau in

2012, the individual shared that finding the cultural context in spite of coming from a more Westernized place.

> My units are something meaningful to me. I like listening to legends….Our legends are ways of communicating our values: respecting the land, elders, getting along with each other…So I wanted to use the [particular] story as a hook to get students interested, talking about cultural values and pull some mathematics out of it. That's the basis of my unit. The cultural practice is the oral tradition, the storytelling. I'm looking at the story and based on the character and the story itself, getting an idea of what I want to do…I'm creating investigations, experiences…to engage the students in working together.

This participant's goal seems to be interpreted here to be to create learning experiences steeped in cultural values and to get the children to cooperatively engage in problem solving experiences.

Several MACIMISErs focused on local counting and measurement systems in their units. One MACIMISEr created a story about a magic necklace and had first graders creating patterns and counting while making necklaces. Another MACIMISEr authored a story wherein the characters were using different items found in the local environment, such as coconuts, to measure height. One pair of participants had children making hand brooms and another participant had students counting and adding with native plants.

For the fourth and sevenths grades, students experienced creating bark cloth designs, building traditional houses, visiting at historic sites such as Nan Madol on Pohnpei to explore local measurement units, and weaving a ball and playing an

accompanying game to explore pattern and function. These are just some of the contexts that were the basis of some of the units. A useful future study would be to look in depth at the different contexts of the units and at the units themselves.

Perceptions of Community Constituents

In doing the research, designing and implementing the units, MACIMISErs experienced some similar and different issues. One major difference was how using cultural activities in the classroom was perceived by those outside the MACIMISE group. When I was beginning to research possibilities for my unit, I reached out to a Native Hawaiian cultural practitioner named Val Ching Jr., who had studied the kind of cordage and knot work the ancient Hawaiians used for utilitarian purposes like fashioning kōkō (nets) for carrying water and food calabashes. When I approached him, he was very enthusiastic and helpful, going so far as to reach out to other cultural experts who had expertise in local practices and possibly the mathematics native Hawaiians engaged in. In the end I chose not to pursue that practice for MACIMISE (in part because I didn't have enough time to become proficient in the practice). But the enthusiasm that Val Ching Jr. exhibited was not true for all cultural practitioners in other participating island groups.

For example, when one MACIMISEr was conducting interviews in the community, some questioned the role of ethnomathematics in the classroom.

> People thought that including cultural activities in the classrooms will only confuse students and perhaps take away time from students learning the actual mathematics that they need in order to excel in later to raise their tests scores and help them in more advanced schooling.

Another participant talked about receiving resistance from elders who said that learning the local counting system was "not important" and shared how another elder said "it's easier to do the Western numbers. So don't make it difficult for them [the students]." MACIMISErs also shared that parents were concerned that the students would not be doing "real math."

This pushback might be explained in part by the degree of cultural pride within a given island community. Hawai'i has had the benefit of some forty years of what's now called "the Hawaiian Renaissance," during which native culture has achieved a new degree of respect and integration within the larger culture of Hawai'i—so much so that even the Hawaiian language has been revived from near-extinction and is being used to teach K-12 curricula to a small but growing number of students who are taking new pride in their native culture. The idea, therefore, that indigenous intelligence could be integrated into conventional academia isn't new, and it's being embraced throughout Hawai'i in a number of different domains.

That may not necessarily be true of other island groups, where native culture may still be seen as inferior to Western culture, just as it was in Hawai'i not even fifty years ago. To teach indigenous knowledge in school, then, could be viewed as anathema, as something that could hold students back from participating in the dominant global culture. Several MACIMISErs, at different times, shared how they had difficulties initially convincing "higher-ups" and teachers to agree to allow the piloting of the units. Even I had to justify the activities I was doing in the fourth grade class where I piloted my unit. The principal asked questions such as "How does what you are planning to do

support the mathematics curriculum the students are supposed to be engaged in? How does it support and extend what they are already learning? How does it fit in?"

MACIMISErs had to overcome widespread perceptions that their cultures didn't think mathematically. When talking with educators as they designed and implemented their units, MACIMISE participants reported that other teachers and educators thought, "that mathematics is something that we did not have in our culture." Teachers they interviewed shared that "we learned our activities by observations and participation," and that that was somehow different from mathematics, because mathematics is "numbers and equations." My experiences as a student, teacher, and teacher educator is similar to those that these participants shared; because of generations of mathematics being taught as skill and drill, students and many teachers never learn nor experience what I believe mathematics really is, a "science of pattern and order" (van de Walle, 2013, p. 13).

In what language should the units be written?

In some locations, teachers were required to teach in the local language, the vernacular. In others, teachers were required to teach only in English. This posed problems for us as curriculum authors: What language should we write the units in? One participant shared.

> In the primary grades, teachers are required to teach in the vernacular. So when we write up our lesson plans, do we write it in the vernacular? It would be very difficult to write the plan in English and translate it because the language is very difficult to translate and the hard part is when we're going to be teaching it to the kids.

A project leader responded that the lessons should then be written in the vernacular if it were the most appropriate; it would be up to the NSF and evaluation team members to figure out what was being done in the classroom for project evaluation purposes.

On one island, the official policy of the department of education was all instruction in English. However, the home language was still very much in tact outside of school. A MACIMISEr shared a personal struggle.

> Another thing to consider is the language that the cultural activity is going to be held, in reference to the language of instruction that is the department of education's policy…Maybe we should write it in both Samoan and English so that the teachers will be able to use it. But in the cultural practice that we're using, there are some Samoan words for which there is no English translation. So we have to define the terms in the Samoan language and I don't want to put the burden on the teacher in the classroom and force them to use the Samoan language, which the DOE doesn't accept.

Hawaiian immersion schools had been struggling with something similar. All Hawai‘i students are required to participate in yearly testing from third grade and up. When the students were being assessed, the test needed to be written in Hawaiian. But, when the test was then translated from Hawaiian back to English and then back to Hawaiian again, it made no sense. In many instances translations between English and the various indigenous languages in the Pacific cannot be directly or clearly made. In many cases the translations are not even possible.

We needed to consider the language(s) that the teachers' were required to teach in, the language(s) the teacher(s) were able to speak and the language(s) the student(s) were able to speak, and to what degree each constituent was proficient in each language. Further complicating the issue was how the languages and cultural contexts may or may not be able to be translated, or had or had not been translated to accommodate mathematical language requirements.

A participant shared what the teacher needs to consider when teaching the lessons in the unit.

> If they are speaking English, then use that language. If not, the teacher has to consider how much the students can listen and try to make meaning. Generally speaking, bilingual is the way the student can get the idea…When I was working with the first graders, I have to use Marshallese so that they can understand.

This participant made up a story about a magic necklace to begin the unit for the first graders before students counted and made patterns to make necklaces. "In order to make the book, I have to use the national spelling. I have it in English and Marshallese. I still need to give it to the Marshallese language specialists."

A participant from Palau shared that the lessons would be taught during the Palauan language block of the school day so as not to intrude on the mathematics section of the day. "Since the lessons are going to be taught in Palauan classes, it will be taught in Palauan. They are for the Palauan curriculum so they will be taught in Palauan." I had experienced something similar. I had to teach my unit during the students' social studies

and science blocks. That way the students could do the mathematics required in their textbooks and the mathematics that we did would be "extra."

Gender issues in the cultural activities

A group of MACIMISErs was struggling deeply with some issues related to gender and shared about this in a talk-story session in Palau in 2012. The cultural practice they chose was weaving. However, weaving had been traditionally reserved for only females. I'm not sure how they resolved the issue, but gender issues came up again at least twice in different discussions.

First, a MACIMISE group was working together to use traditional house building as the context of their unit. Traditionally, house building was reserved for males. However, the context was being taken into classrooms where there would be both females and males. In the end, one MACIMISEr justified that it would be acceptable to do this because the knowledge and skills of traditional house building were being lost and this was a way to help preserve it. Gender, because of this modern problem, became a non-issue.

A second time, during a Plan B conversation in 2013, another participant discussed a unit that included weaving an object, usually reserved for females, that would be used to play a game, traditionally played by men. Advisors asked how the gender roles were dealt with. The MACIMISEr shared about piloting the unit.

> We had one male elder who came to class and he talked about how to play the game. And the next day, I had an elder woman come to my classroom to weave [the object]. The males played the game while the females weaved…Both the

> elders say: the males play the game and the females weave. But today, we are teaching even the boys to weave [the object]. But in the past, only the females weaved…while the males play[ed]. When it comes to playing the game in my lessons, only the males play[ed]…while the female students clap[ped] for them. [However,] when we were doing it, the female students were complaining: they want[ed] to play. When the male students were playing outside, the female students were hiding in the classroom and playing their own game.

This excerpt provides a perfect transition for the next the next chapter. Is it a violation of the cultural activity to allow genders who were traditionally excluded from participating in particular aspects of cultural activities to be allowed to participate because the cultural activity was then being done for another purpose, for school and mathematics? And then might there be repercussions when other community constituents learn that traditional roles may be being violated while children are in school?

CHAPTER 9

CONTRADICTIONS AND VIOLATIONS

There have been many criticisms of ethnomathematics. In *Understanding Ethnomathematics From Its Criticisms and Contradictions* (2009), do Carmo Domite and Pais present:

> Given the radicalism of the ethnomathematical program (at least as it is put by D'Ambrosio (2002)), it is not surprising that its emergence has been the target of strong criticism. In our days research on ethnomathematics is numerous and scattered around the world. It's difficult to have an international perspective on how ethnomathematical research is being done. Hence, to criticize something with so different practices and discourses as ethnomathematical research could result in an unreal chimera, if we don't take into consideration the different contexts in which research is made. (p. 1474)

If there is one thing I am trying to accomplish in this dissertation, it is to allow perusers the opportunity to understand the many different contexts contained in MACIMISE tasks. Although according to Rowlands and Carson (2002) "Mathematics is universal because, although aspects of culture do influence mathematics, nevertheless these cultures do not determine the truth content of mathematics" (p. 98), I argue that privileging "modern, abstract, formalized mathematics…precisely because it is an unusual, stunning advance over the mathematical systems characteristic of any of our ancient traditional cultures" (Rowlands & Carson, 2004, p. 331) is a sterile and impoverished perspective. When an attempt to distill knowledge into an "essence" is

made, so much may be lost. The following sections are examples of ways in which distillations were attempted, some successfully and some unsuccessfully and how these distillations are full of contradictions and violations.

"It's always been to take what works elsewhere and expect it to work [here]."

A participant from Chuuk shared that most teachers teach the traditional "American style" mathematics. "There are some others who are young [who] don't have a full understanding of the culture. With the older, using the cultural way of mathematics won't be a hard thing for them. They already know." But how can this participant be sure? This participant shared that "I haven't really tried out these cultural approaches…They make us use textbooks." Another participant from Chuuk also shared.

> Culture does matter in children's learning. Not only to understand content, but to build a child's person and identity…It's always been to take what works for Western schools and what works elsewhere and expect it to work, totally ignoring and considering if it is relevant to culture…I have always been lacking not only in math but also in Chuukese culture.

How can we, those of us who are not steeped in our culture, or who think we are but have always used textbooks in the learning and teaching of mathematics, design curricular units based on cultural activities that truly and authentically engage students in the mathematics that naturally exists in the cultural practices? And how can we expect teachers, who might not also be infused with their culture, be able to respectfully and

accurately represent it? Finally, can we take cultural activities that exist in the local environment and move them into classrooms and still keep their integrity?

I have been constantly plagued by a question a consultant raised in one of our first large consultation group discussions in Pohnpei in 2011: “Is it violating the culture, taking an activity, a practice, bringing it into the classroom without necessarily having the individual who brings it into a classroom become an expert in that practice?” When I was first confronted with this question, I did not yet understand its complexities. However, after my experiences through engaging in the tasks required by MACIMISE, my answer is yes; it is a violation of the culture. A year later, after much research into ethnomathematics and after confronting these difficult issues, I explained about how I was feeling to a participant during a talk-story session in Palau in 2012.

> I don’t want to take a cultural activity and put it in a school context and have it be disrespectful to the culture and to the cultural activity. When you take a cultural activity out of its original context and put it in a new context you decontextualize it and then recontextualize it into something that it was never meant to be. And, in that, you lose its essence. Just the fact that we’re taking something and putting it in the school, we are changing it. And is that OK?

These and the following are examples of the theme I labeled “contradictions and violations.” This is not to say that these contradictions and violations are necessarily negative. They do, however, illustrate the complexities associated with the goals of MACIMISE and the social and educational realities of our islands. Is it even possible to find indigenous mathematics in our Pacific island communities? And if we were to

uncover indigenous mathematical knowledge, could we apply them in educational settings? And should we? A participant shared.

> I was kind of like in a tunnel, just going for the lesson, kind of forgetting the cultural activity. A friend asked me a question. The math versus the culture. Is it equally being represented in the curriculum? Are the objectives being met as well as the cultural objectives being met? I was thinking, the materials in the house, leaves, rocks, sticks. Maybe that is too "in the surface" and could be in depth.

Again and again, in the conversations in Palau in 2012, I had the perception that participants were tending to neglect, forget, or somehow subjugate what I thought ethnomathematics was –-the indigenous mathematical thought and practice naturally occurring in a culture and its practices.

"I thought of my curriculum unit as something a little more general, relatable to the entire population."

During the summer of 2011 the MACIMISE group met in Pohnpei. Various consultants joined us to facilitate and lead some large group conversations. In small groups these consultants offered input as we tossed around ideas regarding cultural activities on which to base our curriculum units and what those units might look like. I was struggling with the first goal of MACIMISE. I hadn't "rediscovered and/or uncovered indigenous mathematics" and was coming to terms with the fact that I would have to let go of that aspiration. I knew that I could find what I perceived to be mathematics in any activity I engaged children in. That mathematics, however, would be the mathematics I already knew and recognized or the mathematics that the children

would discover, but I could never be sure whether it were "indigenous." I came to terms with my belief that "indigenous," in this context, was unknowable. This was one example of the way in which performing the tasks required by MACIMISE were somewhat contradictory to the project's stated goals.

Once I let go of the aspiration of rediscovering and/or uncovering indigenous mathematics, I could move forward. I could choose any daily activity or practice based in local culture, right? This proved to be just as difficult, however. How could I choose a cultural activity that would be relevant to all the students in an average classroom in Hawai‘i? Unlike some of the more remote island groups involved in the project, much of daily life in Hawai‘i has become so Westernized and of such a mix of cultures that, while some students might participate in what is commonly perceived as local, and possibly indigenous—dancing hula, hunting for pigs, playing the ‘ukulele, making an imu (underground oven), cooking laulau (meat and fish wrapped in taro and ti leaves) and pounding poi (paste made the taro root) or going surfing or paddling—for the vast majority what might be considered a "traditional" Hawaiian practice would be outside their everyday experiences.

And even some practices some would call "traditional" or even "Hawaiian" are neither. The ‘ukulele, for example, is a European import. Furthermore, there's a big difference in Hawai‘i between "local" culture and "indigenous" culture. The former is influenced by the various immigrant groups that have come to the Islands since first contact in 1778: Europeans, Japanese, Chinese, Filipinos, Koreans. Many of them have

been mixed with the native population and have appropriated some of the indigenous culture to produce the fusion we call “local” culture.

How then, could I choose one traditional Hawaiian cultural practice that would be relevant and meaningful for all of these students? I knew, as a teacher, that I needed to choose cultural activities to which all or at least most local children would relate—activities they would find relevant and motivating regardless their ethnic backgrounds. How could I reconcile these understandings with the goals of MACIMISE? Another participant from an island group comprised of two distinct indigenous groups while also very Westernized shared.

> I need to think about not alienating that other indigenous group. So I thought of my curriculum unit as some a little more general, relatable to the entire population including the Micronesians that live there, the Filipinos, Chinese, Japanese and whoever else is there.

Was this the intent of MACIMISE? Or was this a contradiction? Or was this part of the exploratory nature of the project?

If ethnomathematics is the mathematical thought of an identifiable cultural group, and I could not identify a cultural group, could there be ethnomathematics? Could the mathematics found in local activities and practices within this fusion of cultures be called ethnomathematics? And because the local culture is so steeped in outside values, predicated on dominant mathematical ways of thinking that were transmitted and perpetuated through schools, was there any possibility of finding mathematics that would

be any different than the everyday mathematics that exists in any other geographical location with mixed ethnicities in modern day society?

It would be a violation for me to implement a unit in a Hawaiian Immersion school.

One way I might be able to deal with this issue, I thought, would be to implement the units in a Hawaiian Immersion school. In Hawaiian Immersion elementary schools, all instruction is conducted in Hawaiian until fifth grade, when students begin to receive one hour of school instruction in English per day. A Hawaiian Immersion school would be the best setting for a curriculum unit based on a traditional Hawaiian activity. However, this was problematic because I am a cultural outsider. Although I have Hawaiian blood, I was raised separate from the Hawaiian culture, with my haole family. Because I do not speak Hawaiian and was not raised as a Hawaiian culturally, I felt that I could not effectively design and lead curriculum for those who ʻōlelo Hawaiʻi. In addition, it is my belief that it would not be respectful, to attempt to do so. It, in my opinion, would be a violation.

"I had difficulty in the very beginning just with the definition of ethnomathematics."

Some places in the Pacific, such as Hawaiʻi, have become so Westernized that local culture no longer represents traditional values, beliefs and practices. Global society in general privileges capitalist and consumerist ideals; so too with many local cultures. For example, while pre-contact Hawaiians had no concept of private property, modern-day Hawaiʻi is predicated on it. The dominant view of success as being the accumulation

of wealth has overwhelmed traditional values including the idea that wealth is expressed as a healthy relationship with the ʻāina (land) and with the akua (spirits). One participant from Pohnpei shared, "Modern civilization has continuously intimidated our traditional ways of living. Many Pohnpeian traditions have evolved with modern influences, and they continue to change as the dollar remains the sought-after solution to every people's dilemma." In Hawaiʻi today many, if not most, students are concerned mainly with sports, going to the mall, the latest fashion trend and popular Hollywood movies and music.

In the summer of 2011 one participant shared about grappling with these very issues. Most students from the particular island didn't participate in indigenous practices,

> But I still feel that there's a need for the connection to the culture in some way…I want to focus on something that either causes some kind of conflict so that it brings awareness between the past and the present … so [the students] are exposed to how modern [our island] has become.

The participant discussed having students collect data and make decisions based on that data and possibly write letters to the legislature.

> I kind of want to do units that will cause the students to … do the mathematics, talk about the culture … so that they take action, take ownership, regarding the place that they live. … Anything that connects our present to our past is where I want to go with my unit.

A curriculum unit that asks students to take action about issues in their local culture today is valuable, critical theory in action, but is not indigenous mathematics.

In the summer of 2012 I talked again with this same participant. What follows are some reflections about the process for choosing a cultural practice on which to base the units.

> I had difficulty in the very beginning just with the definition of ethnomathematics because our island is very Western…Even though we have indigenous practices, they are not what our people do today… People are trying to create tradition, in a sense of reviving what they think is important from our cultural history. So I believe our students are growing up in that creating tradition instead of revisiting. … My units are something meaningful to me. ... I like listening to legends. Storytelling … permeates through whatever generation. So I wanted to pull that and our legends are a way of communicating our values—respecting the land, elders, getting along with each other. So I wanted to use the story as a hook to students interested, talking about cultural values, and pull some mathematics out of it. That's the basis of my unit ... the cultural practice is the oral tradition, the storytelling. … It's not like I'm having the kids do some indigenous practice.

Other participants also used cultural stories for which to base their units on. Two were local legends and other stories were authored by participants. However, beginning a lesson or unit by reading a story or using a story as a context for academic content, did not necessarily make it ethnomathematics. Did it? The mathematics to be taught was not necessarily any different than the school mathematics that would be taught. Perhaps there would be some local measurement units being used to measure, but was that ethnomathematics?

"I could pull a lot of Western mathematics out of it…I just double-checked the standards."

As we continued our discussions, I began to become convinced that school mathematics and standards were the focus because it was a large part of what was being discussed by many participants. The participant immediately above, who shared about the story as a context of the unit continued to share.

> Going through that process was OK. I could pull a lot of Western mathematics out of it. It was OK for me to think about what I wanted to do based on the character. I picked one [legend] I thought the kids would like…the boy is jumping…thought of kids jumping and measuring. The mathematics is similar, just deeper in each of the grades. So there's measurement in each, some kind of counting, ratio, proportion in each of the grades, based on the Common Core [standards]. I'm looking at the story, and based on the character and the story itself, getting an idea of what I want to do. Then I just double-checked with the standards to see, because you have all these ideas about different activities you want to do, but they may or may not be appropriate for that grade level.

In many instances, participants shared a process of examining standards documents prior to choosing the cultural activity. "As far as the content, we're planning to review the math standards first…[and] after that, we're going to start planning what we're going to do for the units." Another participant shared something similar.

> We came to the point where we need to decide where to start…To look at the [required] curriculum first and look for the math in the cultural activities, or to

> look at the cultural activity and try to incorporate math in the cultural activities based on the curriculum.

And yet another MACIMISEr shared. “I have to also be aware of our standards and benchmarks because our kids get tested. And if it’s going to be implemented, I have to be cognizant of that.”

This is all evidence that the focus turned to matching cultural activities with published curriculum standards and in some cases what the students would be tested on, rather than student engagement in cultural activities and indigenous mathematics. This somewhat contradicts the stated goals of MACIMISE and, from my perspective, violates the cultural practices because they were made to “fit” standards based on Western and school mathematics.

“The activity has to be not only developmentally appropriate mathematically but also culturally appropriate.”

One pair of participants working together to create a unit described a different process. In the first year they had researched a particular cultural practice, creating designs on bark cloth. As they continued they chose another cultural practice, making food. Later, they realized that neither of these cultural practices were ones that first graders would be involved in at home. Therefore, they chose yet another cultural practice in which students might be engaged at home.

> The activity has to be not only developmentally appropriate mathematically but also culturally appropriate. I see kids making a broom. I don’t see them making

> food, which we will have for the older kids…It has to be culturally appropriate as well as developmentally appropriate.

In general, what is considered developmentally appropriate mathematically is that which is stated in the curriculum standard documents at particular grade levels. Therefore, the curriculum units were designed with a particular cultural practice in mind, but focused on the mathematics deemed appropriate by standards documents.

"All the same except using traditional names."

For some islands, the population is still primarily homogenous. With the population comprised mostly of one traditional ethnic group, common cultural activities and artifacts remain today in the cultural landscape. In a talk-story session in the summer of 2012 in Palau I had with a participant considered a cultural insider, I found what I perceived to be contradictions regarding what I thought it meant to be a true participant in a culture and what this MACIMISEr thought it meant. Here I change the format to follow a script so as to provide better context.

> **Me:** "[Another participant] had to get really immersed in the cultural activity and then he was able to see the math that was in it. Are you having that same experience?"
>
> **Participant:** Not really because I was born and raised in the traditional family and went through the experience of all of these different cultural practices. Some of the practices, I did not participate in directly…but I witnessed. I was there when some people [did it]. So I participated somehow, and know, understand what needs to be done.

I found this problematic. It reminded me of a personal experience. Earlier in my teaching career, I struggled to understand what an elementary mathematics classroom steeped in student discourse and problem-solving was. I thought that I had a designed and facilitated a classroom that was highly representative of these processes. I recorded myself teaching and examined the things I said and did for my masters thesis. I found that I was not actually facilitating a classroom culture based in student discourse and problem-solving to the degree that I thought I was. As a cultural insider in my classroom, I was unable to see the aspects of my teaching behaviors that were contrary to how I thought I was until I stepped outside of it and took a very close look. Contradiction existed between what I thought I was doing and what I was actually doing. Is it possible that this cultural insider was unable to examine personal beliefs and ways of participating in their own cultural and educational community from another perspective? We continued to talk-story.

> **Me:** So now what we are putting the Common Core [standards] lens on it, is it affecting the cultural activity?
>
> **Participant:** When we tried to put together our units, we had cultural practices in our minds…But at the same time [I asked], so what mathematics there is? And how do we know? And [another participant] said, well, why don't we look at the standards? But where does Common Core come in? Even now, our DOE hasn't adopted the Common Core. But then we talked, and I said…we're better off using Common Core. We know the DOE is moving toward adopting Common Core. By the time we want to implement these units, at least we'll have Common Core in it,

so the teachers will accept it. Even the DOE will look at it and say, wow, you guys have the Common Core in it. We have no problem with that. So putting together our units, we had to go through a lot of checking back and forth between the cultural practice and matching it with some of the Common Core standards for each level.

Me: Is that changing the cultural activity?

Participant: Not really. We just have to look at the standards that we think is covered in the cultural practices that we're using. We are choosing particular activities at different grade levels, because we want to cover *this* in level one standards. So we know it's easier for them to understand, for the teachers to understand, for the students. So we did it that way. We move up to level four, we're going to use *this* cultural practice because we think students this age can do it, understand the process, and let's look at this standards that are covered in this cultural practice and so forth.

It became commonplace that MACIMISErs focused on the school mathematics either before or after thinking about the cultural practice. "We are going to look at a cultural activity, study it deeply, bring out all the mathematics we can bring out of it, and then take this mathematics and align it with the mathematics curriculum." Another participant from Pohnpei shared similarly.

We'll work with our elders first, then identify the math that exists in those activities, then look at our curriculum. We already know that the FSM [Federated

> States of Micronesia] math curriculum is similar to what the US is using. So maybe we have to see if Pohnpei has one of its own.

A year later, in 2013, yet another participant reflected on the process of designing and implementing the unit. It was indicative of how the individual was using a cultural artifact to engage students in nothing different than the school mathematics and as was in the published curriculum.

> Ethnomathematics is one way of helping the students…understand the mathematics that we are teaching them…If they know that the mathematics has been used in their culture…it will help them understand what is being taught, what I am trying to teach them in the classroom.

Here, again, is the supposition that what teachers are trying to teach, the school mathematics, is the goal rather than the indigenous mathematical thought and actions that may exist naturally in a cultural activity. This participant continued.

> The things we are doing are very much compatible [with the published curriculum]. They are trying to get children to find such things as area, length, width. And what we are doing here is the same except that we are using indigenous names and tools to come up with basically the same stuff…All the same except using traditional names.

These are all what I perceive as examples of contradictions or violations. First, are there really any indigenous practices left? And how do we know? And who decides? A second issue was that for many of our islands, traditional culture has been replaced over time so that a new culture, predicated on consumerist and capitalist ideas, make it nearly

impossible to design activities to be used in schools if they are not related to that paradigm. Third, schools continue to value and rely on published textbooks and are required to follow local standard documents, which are designed around, if not wholeheartedly taken, from those of the mainland United States. Fourth, if our island communities are multi-ethnic, do activities need to be designed so as not to alienate or leave out any particular culture? This may negate the possibility of designing units based on the indigenous and traditional culture that existed before. Finally, as outsiders, or too much as insiders, either to a culture and/or to education, sometimes it is difficult for us to see beyond the structures that are in place, those governed by modern values in a society and published curriculum standards, to be able to perceive different ways of knowing. A consultant asked some questions at the end of a circle that summarized this last issue well.

> Another question that has been triggered for me has something to do with something Andrea said. What is the mathematics in the practice? Is it the actions? In any cultural practice, how is it that we are identifying the mathematics? Is it because it relates to the things we know, from say, school mathematics? Or is it something else? How do we identify the mathematics of a cultural practice?

"So when I'm doing the counting, I'm keeping it simple because that's what the standard says."

An especially illuminating conversation I had in Palau in the summer of 2012 is indicative of the multitude of complex issues MACIMISErs experienced. Three participants and I talked story. I decide here to keep the genders of the participants

because gender roles became part of, what I perceive as, some of the cultural violations we were engaging in as part of the project's requirements.

I present the conversation as a script and label the participants for clarity. One is labeled "elder expert" because he had the most intact cultural knowledge and experiences working with elders while growing up. The other male is named "mentor" because he is an experienced teacher, who had been assisting "young female" who does not come from a teaching background. "Mentor" shared about how he had been assisting "young female" while in her process of creating a unit.

Me: When you're watching the whole process, what are you noticing?

Mentor: We first had a lot of struggle. In the beginning, it was not all set…They did not say "This is the outcome." It's given little by little. These are the things they say, and then we do it. And then there was another change and then there's another change of format.

Me: Are you having any personal issues with the content of the curriculum? The math in it? Are you having personal struggles with what you're seeing happening?

Mentor: The other issues about math and the culture and all that is not present with her work because it's purely counting in Chuukese. The only thing that is a little bit Western there is to interpret the Chuukese counting in English. So you still have your counting numbers and what it is in English.

I was confused by this statement; I had had conversations with other participants about how there were, in fact, some issues with the many different counting systems on this island. Therefore I continued to probe.

Me: Does it match up? Are the cultural differences in the counting making it difficult? Because of the classifiers?

Mentor: Maybe.

Younger Female: Can I interject? I think that, when we look at counting one to ten for the first grade level. They say, OK, one to ten in English. Now, OK, one to ten in Chuukese. And I don't believe that, at this time, anyone has looked at those standards and said, but there's more to counting in Chuukese than just the basic one to ten. So we have produced generations and generations of who, there is this disconnect, because they're not fully fluent in Chuukese, Chuukese counting one to ten, and they're not really fully fluent in English. I don't know how to describe it, but we want these two things, to be local smart and to be global smart. We are nowhere near there. Because of the way the standards are…And that's what my lessons are addressing. Yes, there's one to ten in English, but one to ten in Chuukese, that's a whole different thing. There's a different way of counting flat objects, one to ten, round objects one to ten, that have always been glazed over.

Me: So you have the actual words, and you have the idea one to ten, and flat, but is it something other than physical, like another level of knowing that can't be expressed? For example, it's my understanding that there might be some cultures that just don't think of something by itself and in order to count one, that sits by itself. By just the act of counting the way that we count, changes how they view the world.

Mentor: Yes. It's not in the unit, though. But I came across something in my research. Even at present, when people from the island talk with people from the outer island and they ask, how many coconuts can you donate, and they say 10 trees, but actually some people told me, it *may* be exactly 10 trees, but it *may not* because when they say 10 trees they are approximating that for each tree they mean about 30 coconuts and according to the one who I interviewed, they understand each other that they were talking about the number of coconuts and not the number of trees. When an owner goes to the coconut plantation and says, I think I have 7 trees, I don't know, but the rationale for that according to the one I interviewed is that, when they carry coconut in a basket, this basket contains 15 and this other one contains 15. That's how he explained it to me.

Young Female: There's this emphasis on exact quantity of things in the Western. If there's two; there has to be two. She asked for two; give her two. But, there is a culture around this number—one.

Elder Expert: Because social class is also important in counting. If somebody asks, can you give me a fish?

Young Female: You never give one fish. You never. If somebody asks for one, I cannot just give him one. I make it two. If he says two, I will probably double it to four. I don't listen to the number, if he wants one, I am not going to give him one.

Mentor: There's the respect.

Young Female: There's a whole tradition around this.

Elder Expert: It depends on the social rank in the community. One can be ten, one hundred.

Mentor: Even the classifiers. The classifiers, men. It always says in Western books and those that do research. The classifier for living things. But there are some [objects] in there that are included in that counting that are not living things. Like the art of self-defense. When you count, I have ten skills in self-defense.

Young Female: They don't say ten, like, objects.

Mentor: Yeah. It's ten men.

Young Female: Persons.

Elder Expert: The counting in self-defense depends on how many challengers you're going to face.

Young Female: So when I'm doing the counting, I'm keeping it simple because that's what the standard says. Some of the words, you cannot translate it into English. It sounds funny.

Elder Expert: [A consultant] said, how can you be a Yupik teacher in a Western school? I really like that. We can count, but the spiritual aspects and the respect are not attached. In our training, when we are taught by the cultural elders, you are taught in a way that you will not only get the concrete meaning, but also will put you in a situation where you experience the spiritual part.

Young Female: There are times when we say the number of fish, as living things or animals. When the fish has exceeded a certain size, we use a word that

means, as in no classifiers. So it's more complicated than what we're putting in the units.

"But it's not really what we would be doing in our culture."

Several other participants shared their struggles with the lesson plan templates that were given to us in Palau in 2012 and how to deal with issues of beginning with either the mathematics or the cultural activity. Here is an excerpt from a talk-story session with a different pair of MACIMISErs from the same island. I asked about what their understandings were about what we were doing and if some of the ways they had thought in the beginning changed over time. They brought up a struggle as being the difficulty they were having when they went to write their units and put them into lesson plan format.

Participant A: Because the culture is oral. It's hard to document.

Me: I think part of it is—when we live, it's a dynamic process.

Participant B: Right, right.

Me: Things immerge and then we participate in it in different ways. And when you write it down it becomes something finite. And it's like, OK, now it's done. But it's never done.

Participant B: One of the biggest struggles we had was, does the math come first, that we are supposed to teach, or does the culture come first? And then, when we went math first, then the culture was trivialized. It was un-cultural, a-cultural. Then, when the culture came first, then there was so much math that we that couldn't make it uniform, as a lesson, a unit, they usually

are thematic, focuses on one or two topics. But when it's culture, there's just so much math, there's so many topics so it's like "now what?" That's the biggest struggle that we had in the beginning and we're still having that struggle. So it's an endless struggle. There's no real answer. At least for me.

At a later time that day, I met with yet another two other participants from yet a different island, who were both designing units for first grade. They were also struggling with documenting the cultural practices and making them fit into the lesson plan format.

Participant C: I'm struggling with coming up with my units because first of all, I am not familiar with curriculum writing, especially a unit. I don't know how I can put my lessons together into a series, a sequence that's related. Especially because you are dealing with cultural concepts, to put it in the Western format.

Participant D: Since we have the Common Core now, we are trying to do our activities so that they can look, like [Participant B from above] mentioned, we're trying to do things that are not really the way things are done, but just for the sake of these lessons. We are writing it just to write it, but when we do it in the culture, we are not doing it in the same way.

Me: That's what a lot of people are telling me. Now, it's getting to the point where we are writing it just to write it.

Participant D: Yeah.

Me: But, it's not really what we would be doing in our culture. Do you feel the same way?

Participant D: Yah. Like when we talk about measuring how much water to be put in coconut milk and mix it, that's something we don't do. But since we are trying to teach this, we want to do measurement and volume, and so we may use this just for that.

The discussion changed as we discussed how real life is different than school life. In my opinion, writing lesson plans for school implementation violates how the cultural activities would actually be done in reality; the schools privilege specific structures that are generally foreign to indigenous cultures.

Participant C: Yeah, because all of the learning in the culture is in the natural setting. We don't go according to time, 45 minutes. It just takes place whenever it's ready, whenever time permits it permits.

Participant D: Just weaving will take more than an hour for little kids to weave.

Participate C: Yes. They need to see a lot of things in the community. When you try to compress it into a forty-five or fifty-five minute class, it's a totally different way of teaching. But with all the changes, it's better that we teach it now rather than never. Before it's too late.

It was common throughout the entire MACIMISE journey, that there was a sense of urgency developing in what the participants shared, particularly in the data collected in 2013. So, whatever we were doing was "OK" because we would be losing the knowledge otherwise. Soon it would be "too late" because the knowledge was disappearing or almost gone.

"We want to step outside enough…"

In one of our first whole group discussion in Pohnpei in 2011, a consultant shared what I believe is indicative of the process we ended up going through. We have struggled so much to meet the expectations of the project, the project funders, our local societies as well as research as a whole.

> [A participant] brought up the picture of the house yesterday. At the end you could look at it and see squares. You could see certain geometric figures and use the Western language of mathematics, school mathematics to describe what you see. And the end of this project, we need to have a house so that when the NSF looks at it, they can see squares and triangles, lessons for first grade, lessons for fourth grade, lessons for seventh grade. But that doesn't mean that we're thinking of that while we build the house. Right? I think there's a really powerful analogy there. We want step outside enough to hope that it is, at the end there to look at, but that process is what we're talking about right now.

"Be up front with students about what it is that you're doing." "You're teaching about much more."

In an attempt to sum up the chapters is Part II, I now present some excerpts from a whole group discussion in Palau in 2012. A participant shared. "We're talking about gender issues." What was to happen when a cultural activity that was reserved for one gender would to be taken into a classroom where genders were mixed? A consultant responded. "How authentic does is have to be in a classroom? Is it OK for both genders to be doing [the activity] for the purposes of learning math?" And another participant

shared. “Who gets to answer that question?” Finally, we were left with one consultant proposing. “Who needs to answer that question for you to feel satisfied? That’s the answer.” I felt unsatisfied. This seemed very much a violation of the culture and cultural practices, to me.

However, upon further discussion, another consultant shared about how this may be possible by informing students explicitly of the purposes of bringing the cultural practices into the classroom and about their involvement in them.

> What I’m hearing you saying is that it’s really important to keep the culture as part of what students are engaged with so that that isn’t lost. At the same time I think it’s OK to say, “OK. Now we’re going to look at this cultural activity from a different perspective.” And just be up front with the fact that now we are going to do a kind of translation for the purposes of engaging in school mathematics. Because that’s the other responsibility you have. Be up front with students about what it is that you’re doing. And why you’re making this translation.

Finally, another consultant shared about how in anthropology there are opposite perspectives, the familiar and unfamiliar.

> In a way you can use that approach in your teaching. Sometimes you know things better if you can look at it from these two perspectives, one may be strange and one may be familiar, and how they’re both trying to accomplish something similar, but not quite similar. And so that may give the kids a better foundation. And then on your side, counting in your language is going to be richer than just counting from 1 to 10. And so you’re teaching classification and you’re teaching

about objects, you're teaching about much more. You're teaching some logical reasoning as well.

PART III

ONE LAST CIRCLE

In the introduction to this study, I discussed how I found the most widely used and accepted format of dissertations unable, in my opinion, to honor the research process and the participants in MACIMISE and provided specific reasons for my deviation from the standard format. Typically, in the common dissertation, at the end of the paper, the final chapters would present the discussion, conclusions and implications for further study. That had been my original plan. However, in the spirit of emerging constructions, I deviated from that plan.

Instead this last part, I present "new understandings." It functions as my discussion, conclusions and implications for further study. The reason I am doing it in this way is because it is my belief that in island and other indigenous cultures around the world, it's very rare for a single person to come in with a linear process and idea and reach conclusions that everyone accepts. Rather, the way that conclusions are arrived at is through discourse, social participation and relationships that form among the group. Therefore, the first part of the "conclusions" will be presented as "talking-story" within a circle.

In the Chapter 10: Welcome to the Circle, I offer some quotes I believed were illustrative of some "takeaways" from participating in MACIMISE. I attempt to bring the research again full circle by presenting them as they might have arisen through "talking-story" in "circle" and while "passing the talking stick," although they did not necessarily arise in that order naturally. In Chapter 11: What is Ethnomathematics? To Me?, I provide a brief summary of what others have written regarding ethnomathematics and synthesize their words with my experience in MACIMISE to form my own personal

relationship with the term. The result is my own definition of ethnomathematics; it is one of the results of participating in this wandering, wonderful and illuminating journey. Finally, in the last chapter, in an attempt to satisfy the part of me that wants some sort of "ending," I present some personal conclusions.

I now invite you to sit in circle with us.

CHAPTER 10

WELCOME TO OUR CIRCLE

This chapter is in seven sections. In each section, I chose quotes from Plan B papers and conversations as well as our last "focus group" talk-stories in Honolulu in May 2013. Each section loosely represents a theme, although I am somewhat uncomfortable presenting it in that fashion because what I am really attempting to do here is to engage you in our circle, "leading" as little as possible, in hopes that you will imagine yourself with us, adding your thoughts and reflections as you interact with what we shared.

Section 1: Learning From Our Elders

In general, we gained many new understandings, knowledge and skills and as a result formed new beliefs and values. Part of this was because of working with elders and experts in our communities we may not have otherwise had the opportunities to.

MACIMISEr:

'"Because of visiting with elders and experts, it forc[ed] me to reflect on how much I know about my own culture. I considered myself as well educated, but when I entered these traditional cultural activities, I had a lot of first time (aha!) experiences and encountered knowledge about the culture that I did not know before."

MACIMISEr:

I agree. By meeting and learning with elders, I learned not only about conducting research, but I also now "see the beauty and complexity of my culture, which I would not see otherwise."

Through conducting research while working with these experts and elders, we found new appreciation and pride in our cultures and our cultures' past accomplishments. Many of us considered it a privilege to learn about our culture and expressed that we were honored and humbled by the experience.

MACIMISEr:

"The stories [the elders told] were so lovely, and yet [it's] sad because so many of the practices no longer exist today. Some knowledge holders don't share their skills to anyone but only to close relatives or people in the family. I was fortunate to work with very thoughtful people who were happy to share their knowledge for the purpose of educating our children now and in the future."

MACIMISEr:

Once, when meeting with a group of elders, just one or two elders in the group gave most of the responses "as if they were speaking for all the elders in the group. One elder would never disagree or contradict another elder because of a fear of revealing their shortfalls…I had to be sensitive to the tension among the elders" and find ways to redirect questions to the elders who had not shared.

MACIMISEr:

"I had no idea how complex the mathematical ideas could be until I met with the practitioner. The work was so detailed, so structured, so innate. I had a hard time fathoming what he was trying to share with me. How it was even possible. And yet he was so comfortable with it. It felt a bit 'out of this world.' I guess I can only describe the experience as spiritual."

MACIMISEr:

"I am most honored that I was able to conduct research about my own culture. I realized that I am one of very few people who've done work to document the Kosraean values and knowledge that we have."

Section 2: Learning About Our Cultures

Many of us thought that we knew a lot about our cultures. However, through engaging in MACIMISE tasks, many of us discovered that we didn't know as much as we thought we did. Some of us realized how little we actually participated in our cultures because of outside influences and the daily duties required to participate in modern life.

MACIMISEr:

"I thought I was aware of everything in my culture…but it is only in my mind…I'm so busy with my everyday life…I don't practice what I was raised with...I don't participate in customs because of my work."

MACIMISEr:

I've realized that "in my island, everybody always talks about cultural preservation, but it's just lip service…Nobody is doing anything about it…Everybody says over and over, preserve and conserve [the local culture], but we're losing a lot and I don't think we'll ever be able to catch up or make up those losses."

MACIMISEr:

"Being involved in the MACMISE program has opened my eyes to many things. First, it has allowed me to see the genius in not only the Chuukese culture, but also Micronesian cultures."

MACIMISEr:

"I've realized how much we are missing in our culture, how much we have lost and how much there is to preserve and maintain while those who are knowledgeable can still provide their knowledge and skills."

Section 3: A New Sense of Urgency

As we reflected on the loss of our culture and cultural practices, a new sense of urgency to relearn, revive and research about local and indigenous practices was discovered. We worried about the survival of our cultures, our survival on our islands as well as our participation in global society. There was a new sense of pride accompanying the belief we did have mathematics in our traditional. Mathematics was now being perceived as something other than just a foreign invention that was brought from elsewhere and packaged in textbooks. And many of us thought that through including cultural activities and practices in school settings, by working with children, cultural preservation could be accomplished.

MACIMISEr:

I experienced something a little different. "I have learned that our cultural traditions are still very much intact compared to others in the Pacific region." With the passing of our master ocean navigator Mau, "Nainoa [the Hawaiian navigator who learned from that master] has gotten the knowledge and skill…It's an inspiration to us in our islands. The knowledge is still there, but not to the extent that Nainoa has learned and experienced."

MACIMISEr:

"Our ancestors survived living on these islands for so many years. They were adaptive and resilient to changes. Some people might think they were primitive but I think they were very highly intelligent; they were able to survive by making use of what few resources they had in their surroundings. They consistently showed their intelligence through all the complicated activities in our past up to the present moment."

MACIMISEr:

"I believe that my findings will be useful resources to preserve and promote the valued cultural practices in Kosrae for today's learners as well as in the future."

MACIMISEr:

To continue our survival, "we need to expose our own children to our own cultural practices and skills and at the same time utilize the mathematics embedded in them to teach our children the needed mathematical concepts in the global arena."

MACIMISEr:

There is a new sense of urgency that we have "to do it now. … It's a sad case, but you can't be sad all the time and do nothing. The urgency is there."

MACIMISEr:

"Many indigenous cultures of the world have lost a majority if not all of the bodies of knowledge due to colonization and the pressures of western influence. I believe that our island cultures integrated with our curriculum is one way to help preserve our cultures."

Section 4: Learning and Culture are Intertwined

Many of us began to see education and teaching very differently. We began to think that one problem was the belief that mathematics was something that was brought to us from others, never thinking that we had mathematics in our own culture. After learning that our cultures thought and behaved mathematically, we started to develop new goals and aspirations for our futures and new visions of what education could look like in our classrooms and in our communities.

MACIMISEr:

"I was part of the generation of assimilation. They pushed hard for us to learn English." Others in this program "are really rooted" and it "has been humbling." When studying in Hawai'i and the mainland United States, I thought it was important to learn from outsiders. As a result in being a part of MACIMISE "I realized that early education is where we need to focus our efforts and resources" because "at an early age, in the classroom, you hardly find…culturally empowering and validating materials…[Teachers] don't understand the relationship between self-esteem, culture and learning. Through this experience and journey, I've discovered and reflected on it."

MACIMISEr:

"I now see education and teaching of mathematics as inseparable from life and culture. Evaluation and analysis of traditional activities such as fishing techniques, making of fishing tools, constructions of houses, food preparations, navigations, etc., presented me with a greater realization of how the traditional people interact within their culture

mathematically. Most, if not all the traditional activities contain elements of mathematics. Although we are not symbolically mathematicians, we are linguistically mathematicians."

MACIMISEr:

"I have discovered through MACIMISE that math can be Chuukese. I discovered that math curriculum could be experienced, meaningful, practical, and fun."

MACIMISEr:

Being in MACIMISE "leads to my belief now that our culture has mathematics…Some of our cultural practices are so rich in mathematical ideas and concepts. To insert the mathematics reached in our activities and practices into our curriculum, I am sure will help our students learn better because they can relate the mathematics to their prior knowledge."

MACIMISEr:

Before, I thought there was something wrong with the students. Now I believe that "many students perform poorly in mathematics because they cannot relate what they are learning in the classroom to daily activities in their social environment or vice versa. Some have even developed a misconception that the academic content knowledge that they learn in school has no relation to their cultural activities."

MACIMISEr:

"My perceptions have changed tremendously. I now believe that teaching means having the ability and willingness to accept the differences that exist among people in this world due to different worldviews that are influenced by different cultures and lifestyles. In addition, I have also learned to believe that teaching is a shared and mutual

communication process that empowers both the teacher and the student. It empowers teachers by providing them the opportunity to acquire personal and professional competence in dealing with human diversity issues brought forth by students, and students by allowing them to explore their own self-efficacies and their social environments to identify factors that contribute to success in learning mathematics. Hence, the courses that I have completed in the MACIMISE project have enhanced my knowledge base on what teaching is all about. They have given me the opportunity to explore many things that I was either ignorant of or did not know existed…I can say with confidence that I am much more aware of the factors in my students' social environments that impact their learning."

MACIMISEr:

I now have a desire to bring "cultural practices into the classrooms for children's awareness as well as raising their interest and bring[ing] attention to these endangered practices that I believe are very important to the long-term survival of people living on these small islands."

MACIMISEr:

There needs to be better understandings in education, "to create meaningful ways that teachers can teach mathematics that both develop students' math understanding as well as instill pride and knowledge in their culture…having students exposed to the facts that world recognized bodies of knowledge like mathematics exist in their indigenous cultures and practices make the experience of learning more meaningful."

MACIMISEr:

Prior to being a part of MACIMISE, I did not see any connections between culture and mathematics. I thought “everything I was trying to get was knowledge that was not dealing with our culture because that’s what we use in the classroom.”

MACMISEr:

Even as college instructor, my belief of what mathematics was changed. I have a new focus to change “what I’ve been doing…not just knowing the formulas and procedures, but to learn the real mathematics.”

Section 5: We Have a New Sense of Purpose

Many of us are more confident in our roles as teachers and teacher leaders. We thought about how we could do things differently in our classroom because we had experienced the many positive results of implementing cultural activities in classrooms.

MACIMISEr:

“I now have the confidence to help guide my teachers toward looking at the curriculum and get the best out of it and to improve their teaching techniques and methods. The curriculum courses helped me see differentiated teaching and learning styles and methodologies. I learned more approaches that I already pass on to my teachers I am sure are already helping some of them improve their teaching which eventually will help improved students' learning outcomes.”

MACIMISEr:

I hope to increase “my chances of influencing the way teachers on these small islands approach teaching” and to use the newly developed “insights into differentiated teaching styles and methodologies” in their own educational careers.

MACIMISEr:

I have a new sense of empowerment and purpose. “We can inspire others to do something before it is too late.”

MACIMISEr:

“At first when in the program, my goal was to get a degree…We don’t have many chances to get higher degrees.” However, after engaging in all of the experiences, I discovered that MACIMISE helped to teach “the cultural stuff, but [also helped] develop my ideas about how I teach in the classroom. I could feel and see that I want changes in my students. I want my students to learn. Comparing to the ways I taught before, I think that’s a very good development for me.”

MACIMISEr:

“With the revelations we have, we will go and try to make the people realize that there is also math in the culture…make them aware that we can do the cultural math like we can do the modern math. It’s an obligation we are having to change our personal teaching strategies.”

MACIMISEr:

“I’ve come to realize that maybe I should not depend so much on the textbooks…There are many things all around us all the time that we can use as a way of teaching math;

[and] I can see differences between then and now. Then the students were kind of bored, and every time I gave them a test, they always forgot. … Now, it is working. I can see improvement in the things I am looking for."

MACIMISEr:

"Before, I was thinking that culture is important, but I wasn't thinking about it in a classroom situation. As a result of this program…we can teach math through cultural practices…The teacher I was working with, she is just like me, doesn't realize that using the cultural practices [could be used] as a basis of teaching the math concepts…When she tried the lessons…she realized that it's gong to work and it's more interesting to the students."

MACIMISEr:

I worked with teachers and had the teachers write about their experience while using cultural activities in the mathematics class. "One hundred percent of them would like to do it in their classrooms…This program made it happen…We always thought about math as something we get in school and in textbooks, never anywhere else."

MACIMISEr:

When we piloted our lessons, students and teachers showed more interest, motivation and higher participation when the cultural-based lessons were being conducted. "Students really liked the activities. [The teacher's] strategy had been doing [the same] routine [instruction]. So when this new thing goes into the classroom, they [the kids] were really excited." I videotaped the lessons and "in the videos, the kids were really engaged. And it was exciting for me too."

MACIMISEr:

I work with both college students and children. After I explained what we were doing, "some [college students] were interested and some were just looking at me [seeming like they were thinking] can we move on to the next learning outcome please?...But elementary students got really excited."

MACIMISEr:

I teach mathematics for teachers. Before, the students would drop or not come to class. However, because the activities were culturally based and they were doing hands-on activities, "There is perfect attendance. At the end of the semester, they are still there."

MACIMISEr:

"I think the best approach is to go into the schools. There's a lot to improve in our curriculum…It's important to start out with what we have, especially in our culture, to bring in the cultural practice and start there" when teaching. "That's what I think changed…[My] doubts have been resolved. I'm really eager…I want to get into the classroom and try things our like this, and find out if it will work…I really believe it can."

Section 6: We Learned Together; We are More Grounded as Individuals

The newly acquired feeling of belonging and a newfound appreciation of being a part of something important that was going to help bring about positive change was common for us. Our coming together and dialoguing allowed us to engage in new consciousnesses. In the beginning, I was struggling with what ethnomathematics was and how my island was

mostly westernized. Through struggling together, we each reached understandings grounded in other appreciations.

MACIMISEr:

"Having a circle…ties us together professionally and spiritually…this program makes me realize that we are doing math without realizing that we are doing math."

MACIMISEr:

"Circle time with others gives time to think and reflect, to step back and look at it, [the significance and impact] from afar."

MACIMISEr:

The "most memorable and meaningful [part of MACIMISE was] the privilege and opportunity to participate…We come together. We sit in a circle and we share. We empty what we brought from our different islands. We go back and reveal and empty and we share [when we] go back [home]. Then we come back together. We come to know each other and really become a family."

MACIMISEr:

"I think what stands out most in this program is the instructors and the students, participants, are connected together. It makes me feel like I belong somewhere. I share something that I feel is missing from my culture, knowing that the other islanders have the same issues. It does not make me feel so alone and that I am different from everybody else."

MACIMISEr:

"As an individual I am more grounded in my own culture, and more appreciative of everyone's culture…We have a shared vision. [We] are part of the group and stronger as an individual. So there is a comfort level. I have a greater appreciation for what I'm learning, my growth, because of their knowledge."

MACIMISEr:

The most meaningful part of the program has been the "cultural sharing" because "I've learned so much from everybody…I'm already thinking of other things I can do that involve weaving, that involve fishing, navigating and it doesn't seem that I can't do it…It's tangible now. I can really touch it. I can see it…That process is there. Where ever it takes us. But, I know where I'm heading because of this."

Section 7: It's Important to Preserve Our Cultural Identities

We appreciated the circles and of us, as Pacific Islanders coming together, alongside the instructors and consultants. We had new beliefs and concerns regarding how personal and cultural identity are important for children's self-esteem and motivation. And there was a belief that increased mathematical achievement could be achieved when cultural identities were brought to the forefront in educational settings.

MACIMISEr:

"The cultural awareness and importance of including it in the curriculum for the school children is really, really important."

MACIMISEr:

"One needs to know ones' own culture…to have identity…before they can go out and learn about other things. [They] need that foundation."

MACIMISEr:

"Once you lose [your foundation], it's gone and you're no longer what you were. You can look around for want you want to be and never find it. You can never be somebody else. You can always be yourself."

MACIMISEr:

"I never knew who I was. I never felt a real identity. And as a result, I have always struggled with self-confidence and the ability to truly relate to and trust others."

MACIMISEr:

"Being in this project taught me that I need to understand my own culture to be able to reach out to other cultures."

MACIMISEr:

"This project has elevated my knowledge and concerns for our islands. My goal is for children to be educated. I wasn't sure. Are we going to education them to be American and make a lot of money and all that? You can make all the money you want and never be satisfied. We need to teach them so that they will be somebody. And that somebody is within the culture and tradition of who you are."

MACIMISEr:

"At home, they [the children] already learn many things. What they learn in the classroom is totally different than what they learn at home."

MACIMISEr:

“Part of it is breaking down those barriers that have been set up. They’re artificial and they don’t need to be there.”

CHAPTER 11

MY NEW UNDERSTANDINGS

We engaged in "transitive consciousness."

Borba in (Powell & Frankenstein, 1997) describes consciousness as "an endless, recurrent process which embodies, in a broad sense, reflecting, knowing, and thinking, " (p. 262) and that there are two kinds of consciousness. Rather than being "a person with intransitive consciousness," who "doesn't link her/his experiences together; she/he always lives in the present moment and therefore cannot make important connections. She/he is likely to change only superficially" (p. 262), we were exhibiting having "transitive consciousness" because we were developing

> a more reflective perspective which allows her/him to make connections between her/his different experiences and therefore make significant changes in response to these experiences. Freire argues that reaching a "critical transitivity" is necessarily an active and dialogical (that is, in dialogue with other people) process. (pp. 262-263)

Through my dialog with others, and I posit that through others in MACIMISE dialoging with each other as well and advisors, instructors and consultant we engaged in transitive consciousness. Whether or not we reached a critical transitivity is up for debate. However, I believe that we have engaged in "a more reflective process" allowing us to make new connections and an example of this is "what ethnomathematics" now means to me.

What is Ethnomathematics? To Me?

From the beginning of Project MACIMISE, participants believed that they would be investigating and involving students in ethnomathematics. At many different times, participants shared their ideas about what ethnomathematics was and how they thought they were employing it throughout the different stages of the project. Here I present some research and what have become my own understandings about ethnomathematics.

"Ethnomathematics may be defined as the cultural anthropology of mathematics and mathematics education," Gerdes writes, "a relatively new field of interest, that lies at the confluence of mathematics and cultural anthropology" (1997, p. 332). Gerdes goes on to say, "It may be described as the study of mathematical ideas and activities as embedded in their cultural context" (2001, p 2). These are just two of many definitions and descriptions of ethnomathematics from various sources I've read. Like many, they are—in many cases by their authors' own admission—insufficient: vague or subjective, too general or too narrow, with too many undefined terms.

This is because in part that the field of ethnomathematics is still in the process of discovering itself. Questions remain about its usefulness. Arguments endure about whether there even *is* such a thing as ethnomathematics. Mathematics, so the thinking goes, is absolute, universal, pure and therefore acultural. This view does not, however, obviate the possibility that different cultures have different ways of thinking mathematically, and the field of ethnomathematics may usefully consider what those differences are and how they might be understood and used.

According to do Carmo Domite and Pais (2009):

> Ethnomathematics does not restrict its research to the mathematical knowledge of culturally distinct people, or people or their daily activities. The focus could be academic mathematics, though a social, historical, political and economical analysis of how mathematics has become what it is today. As mentioned by Greer (2006), it is part of ethnomathematical research to understand the historical development of mathematics as a scientific discipline, the understanding of that development as the intersection between knowledge from different cultures, and the way the validation of what is considered to be true mathematical knowledge is less related to issues of rationality, than with the social and political contexts. (p. 1473-1474)

For me, a simple, functional definition is the most helpful: Ethnomathematics is the effort to reconnect mathematics to what matters. “What matters?” is the essential question, and its answer is culturally specific. What matters to a fisherman in Palau is likely to be different than what matters to a day trader in Manhattan. What matters to a teacher in a Hawaiian-language immersion school is likely to be different than what matters to a teacher in an English-language school. What matters to a teacher is likely different than what matters to a student, and so on. Ethnomathematics is the mathematical thought and practice of a culture; it is the mathematics underlying the daily activities that define a culture. As such, the mathematics found in a culture reflects that culture’s heritage and worldview—the mathematics that matter to that culture, their Ethnomathematics.

Implicit in my definition is the converse: That there could be a mathematics that does *not* matter to a culture, or to individuals within that culture. This idea might be an anathema to a proponent of pure mathematics, but it's part of the daily experience of almost every student for whom formal academic mathematics is a requirement. A mathematics teacher commonly hears, "Why should I learn this? When am I ever going to use it?" It's a difficult question to answer honestly—perhaps in a culture where any cheap cell phone can be a calculator, there really *is* no good practical reason for someone to be able to perform the standard algorithm for long division. Ethnomathematically speaking, we could say that learning the standard algorithm for long division is not culturally relevant, which makes learning the operation not only difficult but in the eyes of the learner, pointless. Similarly the kind of mathematics taught to indigenous people living on remote Pacific islands might not be particularly useful, or in the worst-case scenario might directly conflict with a given culture's way of thinking about the world. By the same token, for a culture where cheap cell phones are *not* readily and widely available, a different sort of mathematics might matter; perhaps the ability to perform the long division algorithm would be useful. The ethnomathematician is uniquely equipped to recognize these points of disjunction and possibly also to remedy them by developing culturally relevant mathematics education tools; that is, to "reconnect mathematics to what matters."

D'Ambrosio (1985) called ethnomathematics "the mathematics which is practiced among identifiable cultural groups" in contrast to the "academic mathematics" taught in schools. The International Study Group of Ethnomathematics defines ethnomathematics

"as a research field, that reflects the consciousness of the existence of many mathematics, particular in a way to certain (sub)cultures" (Gerdes, 2001, p. 4). To help provide some clarity regarding the "many mathematics" that exist, I will use the term "Mathematics" (with a capital M) when discussing "formal academic mathematics." "Ethnomathematics" (with a capital E) indicates the mathematics that matters to a particular culture and "ethnomathematics" (lower case e) refers to the field of ethnomathematics in general. Therefore, Mathematics is part of Ethnomathematics because it is the mathematics practiced by a given culture within an academic mathematics environment. These distinctions, although sometimes blurry, are important when considering mathematics that matters; a person interested in Mathematics might have different concerns from a person who's turning a bowl—for that person, Ethnomathematics might be more useful.

How might we reconnect mathematics to what matters? Could we define the particular culture or community to be considered? Then could we could observe them, and most beneficially, participate in their lives? By learning about what is important to them and what they think will be important in their past, present and future, could we then try to determine the Ethnomathematics they have and the Mathematics they might need to achieve their goals? These are important questions to ask when considering what mathematics and ethnomathematics should be taught in schools with indigenous populations in the Pacific. Should it be Mathematics or Ethnomathematics? Or a combination thereof?

One important goal that falls within the scope of ethnomathematics that is almost never a consideration in Mathematics isn't mathematical at all: the restoration of cultural

pride and an appreciation of a culture's mathematical intelligence. This goal is certainly true for the indigenous peoples of the Pacific, who have for more than two hundred years suffered the effects of colonization by larger powers and whose cultures have been suppressed, absorbed, and/or replaced. The Hawaiian Islands provide one of many examples.

Pre-contact Hawaiians were skilled resource managers; the Hawaiian Islands sustained a population of between 250,000 and 1,000,000 people for centuries without the use of any sort of modern technology or even metal. Today, 250 years after Europeans discovered the Islands, its society is no longer sustainable: 85 percent of Hawai‘i's food, energy and commodities are imported. In twenty-first century Hawai‘i there is a conscious effort to restore some of these ancient management strategies, and in the few places where they've been applied, they've been successful.

For example, taro farming developed into a sophisticated system in Hawai‘i; while taro was farmed throughout Polynesia, the practice reached its apotheosis in Hawai‘i. Approximately three hundred varieties were cultivated in ancient times, most of them in ponds called lo‘i. Taro farming was laborious and difficult, requiring continual tending, rock wall construction and the maintenance of complex irrigation systems to divert water from a kahawai, or stream, to the lo‘i. A rock dam moved water from the kahawai into an ‘auwai, a manmade irrigation ditch that carried the water from the kahawai to lo‘i and then back to the kahawai after draining off the lo‘i. The kuāuna are the sides of the embankments of the lo‘i that were piled high enough on the bank to hold the water in, and then stamped down until the edges and lines were straight.

Mathematical thinking is inherent in this engineering. Precisely what sort of mathematical and Ethnomathematical thinking isn't known, as the Hawaiians didn't keep written records. It could well be that they used similar geometry as the Greeks, or it could be that they had different ways of thinking about dimension entirely. They certainly applied a sophisticated understanding of hydrodynamics, even engineering the loʻi to handle flooding events so that runoff would not destroy the taro. The kinds of questions ethnomathematics encourages us to explore are: How relevant and useful would the mathematics brought by Captain Cook have been to these farmers? Conversely, how relevant would the mathematical thinking of those farmers have been to Cook? Would they have even been different mathematics? What sort of applied mathematics are used in modern taro cultivation, and how relevant are traditional Western modes of mathematical thinking to it? Can the Ethnomathematics inherent in taro cultivation be effectively used to teach Mathematics to children? The questions can radiate from small applications to grand visions: How can the Ethnomathematics and Mathematics merge to help to create a more sustainable future food base in Hawaiʻi?

If the goal, furthermore, is not simply to teach Mathematics, but to instill cultural pride and appreciation, this sort of ethnomathematics is invaluable. When Mathematics is applied within a relevant cultural framework, it can ignite passion in its practitioners, even help to revive a culture. In the 1970s, after two centuries of suppression, Hawaiian culture experienced a resurgence. Renewed interest in native language, art, hula, medicine and spirituality flourished. One spark for this "Hawaiian Renaissance" came in 1976, when a replica of an ancient Hawaiian voyaging canoe, *Hōkūleʻa*, sailed from Maui

to Tahiti using only natural elements—the stars, winds and currents, birds—proving that the early Polynesians were not just aimless castaways who got lucky in discovering the Hawaiian Islands but rather a culture with unparalleled voyaging and wayfinding knowledge. In 2007 *Hōkūleʻa* sailed to Japan. Plans to circumnavigate the globe beginning sometime in 2014 are being made. Stellar navigation, which requires sophisticated mathematical understanding is not just a useful example of applied mathematics. Pacific voyaging is an example of how science, mathematics and community are integrated in a meaningful way to accomplish incredible feats of imagination and engineering; such mathematical knowledge makes the difference, literally, between life and death. Correct calculation leads to a pristine paradise; miscalculation leads to being lost at sea.

The Hawaiian people, arguably among the most accomplished voyagers in the Pacific, had lost the art of stellar navigation. Only a few people in the Pacific still held this knowledge, one of them being a Micronesian named Mau Piailug. Mau agreed to come to Hawaiʻi to teach the lost art to a new generation of voyagers, including Nainoa Thompson, the navigator who piloted *Hōkūleʻa* to Tahiti, where the canoe was received with joy and tears from the Hawaiians' distant Polynesian cousins. Probably at no other time in modern history has the sharing of Ethnomathematical knowledge meant so much to so many. Mau shared not just the indigenous methods of measuring azimuth and declination; he shared generations of stored cultural knowledge, knowledge that was integral to the ancestral story of the Polynesians. Mathematics that mattered.

Ethnomathematics has pedagogical implications as well. In reflecting on my professional experiences in education and my personal experience of living in the Hawaiian Islands, I've found the relevance of curriculum to the needs and interests of Hawai'i's children to be lacking. The study of history, by way of analogy, is generally devoid of context, so far removed from children's experience that it's too abstract for them to even begin to comprehend. History becomes a dry recitation of names and dates and events, most of them divorced from the immediate realities of children's lives and therefore a chore to learn. Similarly, mathematics education is frequently reduced to rote drill and presentation of step-by-step algorithms, leaving students' mathematical knowledge void of some (if not most) conceptual understanding. Mathematical understanding has become disconnected from practice, from culture, from the realities of everyday life for Pacific islanders. It has become narrowed to a particular cognitive frame, a focal setting that privileges structure over function, content and product over process, performance over comprehension. These methods do not help to build respectful relationships among students, the topics they study and the instructors who teach them.

Indigenous people in colonial or postcolonial cultures are at a disadvantage. The disparity is clear, in educational terms, in science, technology, engineering and mathematics fields, in which indigenous children underperform. Part of the reason is that the foreign educational systems that are in some cases imposed on indigenous people fail to account for their cultural differences. Additionally, indigenous knowledge is often subordinated to the colonizing paradigm, leading to a sense of cultural inferiority. However, indigenous knowledge contains a wealth of undervalued information that

remains relevant to native people in the twenty-first century but which isn't included in curricula. Often this indigenous knowledge can be applied beyond the small communities in which it developed; it can complement or even offer a corrective to dominant modes of thinking.

Relevant questions about real-world situations in home cultures motivate children; they provide a context for learning and problem-solving in Mathematics as in any other domain. And when learning is contextualized and situated, an enduring sense of pride and a connection to place arise. Consider the resources and boundaries of the ahupua'a (sections of land used in ancient Hawai'i and resource management) with its summits, peaks, valleys, hills and passes. Its streams and springs flowing into lo'i, fishponds, and out to the nearshore reefs and islets. Consider the unique winds, weather, and tides. How did the people of Hawai'i sustain traditional livelihoods and, later, develop commercial enterprises in these unique environments? What were the states of ecosystems in the past, and how has modernity impacted them? What happens when traditional systems coincide or collide with commercial, residential and military development? What happens when the understanding of the complex dynamics of an ahupua'a—its mathematics manifest in hydrology, calendric cycles and terrace construction, for example—are replaced by a new culture? What happens when that knowledge, if not wholly lost, is recovered and applied? What sense of purpose and dignity can be inspired in learners when mathematics is applied this way?

According to D'Ambrosio's *Ethnomathematics: Link between Traditions and Modernity* (2001),

> The pedagogical proposal of ethnomathematics is to bring mathematics to life, dealing with real situations in time [now] and space [here]; and, through criticism, to question the here and now. Upon doing so, we plunge into cultural roots and practice cultural dynamics. We are effectively recognizing the importance, in education, of the various cultures and traditions in the formation of a new civilization that is transcultural and transdisciplinary. (p. 34)

What issues do children, educators and the greater society face today? What are their cultural roots? How can we "practice cultural dynamics" in the classroom and take advantage of these varying perspectives? How can the traditional and modern coexist to better encourage stewardship of land, culture and children?

"Conciliating the need to teach the dominant mathematics and, at the same time, give recognition to the ethnomathematics of their traditions, is the great challenge for education of indigenous peoples." (D'Ambrosio, 2001, p. 15) In Alaska, Yup'ik students' mathematics performance improved with the use of *Math in a Cultural Context,* a program developed at the University of Alaska by mathematics educators working in tandem with tribal elders. A study found that this culturally based mathematics curriculum enhanced students' learning concerning the concepts and properties of a rectangle, perimeter and area (Lipka, 2004, p. 17). These concepts consistently prove difficult even for non-indigenous students. This could be a result of these concepts being taught as mere formulae, void of context; when you take something out of a social, psychological or emotional context, students struggle with comprehension and often quickly develop a negative disposition toward mathematics. A Mathematician might say

that the mathematics itself is no different for Yu'pik people than for physicists working at the Large Hadron Collider. But is it possible that, in this example, the Mathematics is the same, but the Ethnomathematics—the way students think mathematically, or the way in which mathematics expresses itself when in a Yu'pik context—is radically different? Is it that the Ethnomathematics succeeded in teaching the Mathematics, and may also have succeeded in another important dimension, one with which Mathematics does not concern itself: Could it have helped restore a sense of cultural dignity among the teachers and learners?

"An important component of mathematics education today," writes D'Ambrosio, "should be to reaffirm, and in some instances restore, the cultural dignity of children" (2001, p. 308). When indigenous knowledge is passed from elders to mathematics educators to teachers to students and community members, how might a culture be revived and celebrated, rather than denigrated and subjugated? How might Mathematics go from something endured to something enjoyed—not dry recitation of formulae, but a vibrant and practical expression of living culture? There are already a number of examples of cultural revival through the recovery of indigenous knowledge throughout the Pacific such as the ones I noted above. When cultural dignity is nurtured, Pacific island peoples can be empowered to offer their native wisdom to the wider world.

Ethnomathematics is an evolving field of study, one that has not yet clearly defined itself. Other so-called "soft sciences" like cultural anthropology, sociology and psychology experienced similar growing pains as they developed, and these fields were often criticized as too subjective, too amorphous, not "scientific" enough to be useful.

But years of study and practice have proved that while they are not as cut and dried as hard sciences, they nevertheless have yielded invaluable insights and methods that have helped us better understand ourselves and helped us to achieve. So too with ethnomathematics; it is *more than* mathematics. It is the mathematics that matters, and by acknowledging that some mathematics is more relevant and culturally specific than other mathematics, we can begin to help Mathematics learners achieve greater insight and understanding, as well as restore cultural pride among those who have been deprived of it.

Bringing it back around—Ethnomathematics and Polynesian voyaging

If anyone doubts the value of the kind of cultural mathematical inquiry we have engaged in, look at the example of Nainoa Thompson and *Hōkūleʻa*'s World Wide Voyage. The recovery of celestial wayfinding in Hawaiʻi is an example of the value of ethnomathematics. While the actual practice of navigating by the stars might itself be similar from culture to culture—the measurements or sort of technical aspects would be the same—they vary in terms of their cultural contexts and what they mean to the cultures that use them. For example, in Hawaiʻi voyaging was a lost art. Wayfinding *was* the way that Hawaiians originally found the Hawaiian Islands and as the culture was decimated over the centuries of contact, the skill of voyaging was lost.

The recovering of that technique had a profound sense of meaning for them, perhaps much more than say a NASA astronomer or a Matson container shipper would, who might use exactly those same techniques. And so ethnomathematics takes what might be some sort of absolute or pure principal—what some consider mathematics to

be—and embeds it in a context, giving it deeply rich and complex layers of meaning. That is the *mathematics that matters* to that culture.

It seems like there is an ongoing debate—whether or not ethnomathematics really is anything—mathematics is not considered by some as a subject that is related to culture at all—mathematics is pure and absolute. That may be true at the functional level, but at the psychological, emotional, social and cultural levels, I propose that it's very different.

Nainoa Thompson found Mau Piailug, a man from one of the most far-flung islands, Yap, to recover the very techniques that got them to Hawai‘i in the first place. He was raised in a Western culture, went to high school and learned Western mathematics. He never learned about celestial wayfinding. Nobody knew of it anymore. It was gone. Hawai‘i was completely enculturated in a Western paradigm. He had to go all that way, to Mau in Yap, to find this ancient wisdom. And he was taught. He came back to Hawai‘i and taught more and now there's an explosion of wayfinding around the world. And a new wave of cultural pride. This sparked an entire Pacific wide revival of voyaging arts that have imbued cultures with a new sense of their own achievement, which they didn't have before. And that's valuable. Apart from the mathematics itself.

I posit that mathematics is valueless except in terms of its applicability of achieving something. There are some mathematicians that appreciate its elegance and purity, as I do. But its not just a tool, it is something that is, for certain cultures, a way of interacting with their world and is a part of their core identity.

That's certainly true for the Hawaiian culture. When you think of the migrations of the Pacific—undoubtedly one of the greatest human migrations and one of the greatest

logical yet pre-technological and pre-industrial human achievements—that people were able to travel immense distances, finding islands in the middle of "nowhere" and populate islands they found successfully. It's just incredible. The odds against it are astronomical. But somehow the Polynesians figured out a way to do it.

It might have been some luck. But they must have "kind of knew" what they were looking for. They knew how to find islands. How they knew, we don't know. Celestial wayfinding is great if you know where you're going. But it doesn't tell you what's out there.

The Polynesians had some direction—the directions of waves under the boat, the location of the birds and the ways they were flying—signs of pointing to somewhere. What is the mathematics that matters? Well, take Polynesian wayfinding as an example of that. It may be the same mathematics for a NASA scientist, or Matson pilot, or a Polynesian navigator. It just matters differently. And that's what ethnomathematics is—looking at and trying to notice, rather than repeat the formulae of abstract, "pure" mathematics to solve problems for the sake of solving problems.

Also, they may have arrived at those mathematical conclusions very differently. Who knows how Polynesians figured out declination and whatever it is that celestial wayfinding involves. I don't know enough about it to speak about it. But, while the function itself is the same, the methods of arriving at it might be very different. And that demonstrates diverse mathematical ways of thinking, knowing, being with and experiencing the world.

CHAPTER 12

SOME LAST PERSONAL CONCLUSIONS

Finally I leave you with some of my last conclusions. I have proposed throughout this dissertation that there were some things that "worked" and some that didn't while we engaged together in MACIMISE. Not I share some of my own personal understandings through my engagement in transitive consciousness that I believe should be highlighted.

1) There are doubts that ethnomathematics is legitimate. Is it just a politically correct "buzz word" that people are using to get grant funding? Here again, I must return to what I described in the previous chapter about Nainoa Thompson as evidence that, yes, ethnomathematics is legitimate. I now even have doubts about whether school mathematics is legitimate. Is it that we are so steeped in our dominant paradigms that we have become stagnant? Have we lost our ability to look beyond what we have done for hundreds of years, unable to voyage, taking the leap to perhaps find some new ways to look at and perceive what mathematics is?

2) Must more extensive research must be done into indigenous practices and languages and of Pacific island groups before knowledge and skills are lost. There is a dire need for cultural preservation. An example from Hawai‘i is the use of the Hawaiian language. In the 1700s, there were an estimated half million Hawaiian language speakers. With the decline of the native Hawaiian population due to introduced diseases and then the overthrow of the Hawaiian government, laws outlawed speaking in Hawaiian. The language was nearly lost. Today, fewer than 5 percent of Native Hawaiians are fluent and the language that is spoken today is not the language that the original Hawaiians spoke

(Williams, 2014). Still, this revival of culture, brought about by a concerted effort to revive the language can be a lesson for other island cultures. Preserve your languages. Preserve your cultures. Before it is too late.

3) The research that must be done into local cultural practices must be done with true cultural practitioners over long periods of time. Cultural activities and practices cannot be treated as simple. They are complex and situational and environmentally specific. They should not be taken out of their original context. Future projects like MACIMISE must devote more time to the research with elders and local experts before anything else is done with the research. Researchers must become as expert as possible themselves in the cultural practice(s). This could take many years. In the article "Hoʻokele Wa'a: Science, Performing Arts, and Hawaiian culture Come Together in the 8th Grade Classroom," Susana Browne quotes 8th grade Kalama Intermediate School science teacher Margaret Prevenas.

> In order to help my indigenous students learn about their culture, I had to learn about their culture…I needed to be able to understand that a native way of knowing is truly native intelligence. I needed to learn about Hawaiian culture and have open communication with an individual or reliable resource that could assist me in addressing the traditional Hawaiian ways of knowing. (p. 8)

4) Ethnomathematics needs to be better defined. The differences between what is culturally-based, culturally-relevant, culturally-specific, etc., must be part of the discussion. The word ethnomathematics, I believe, cannot be a "catchall" term.

5) Teachers, educators, educational leaders, and even the greater community must be informed about the political nature of mathematics education. There must be more understanding about school mathematics and how it is different than the many different kinds of mathematics that might exist in identifiable cultural groups. There are different mathematics. And all of the ways that humans have mathematized their world should be honored. One way should not be privileged.

6) One size does not fit all. Counting is not just counting, particularly in small and more isolated island groups where indigenous counting systems still exist to some degree. Children should be given the opportunity to examine dominant forms of counting and those that existed in their traditional societies. By doing this, they may have a better understanding of counting because they are looking at how systems were different and similar. This can lead to better understanding in general. We can't just take one thing that works in one place and expect that it will work everywhere. We can, however, have children examine the different methods and strategies to form deeper understandings of different forms of mathematics and how different societies think mathematically. Critical curriculum is a necessity. The history of mathematical achievements in local environments and in the global society must be included in schools.

7) It is my personal conclusion that ethnomathematics cannot be done effectively in regular Hawai‘i public elementary schools during the regular school hours. There is too much rigidity in the administrative and HIDOE requirements. Schools are generally expected to follow textbooks and not deviate from them. "What mathematics is

important?" is not a consideration for those in the administration. They are mostly concerned with uniformity, using textbooks and test scores.

8) I believe that textbooks are a hindrance. They are a crutch. Teachers must understand mathematics better to become better teachers. They cannot do this if they solely rely on textbooks. They need to become problem solvers themselves. Teachers must be aware of the different between conceptual and procedural understanding versus rote and algorithmic teaching and learning. There must be a focus on relational understanding rather than instrumental understanding.

9) Educators must become more aware and reflect more about the importance of cultural identity and its relationship to self-esteem, self-efficacy and motivation.

10) When developing units based on cultural activities, we should not look at local and national standards. The mathematics should come from the engagement in the cultural activities themselves. Otherwise, only school mathematics will be recognized. We cannot fit cultural practices into templates. Instead, the cultural practices should be presented as they naturally occur.

11) Being connected is important. Learning communities and long-term professional development is a must. And this development must include reflection about personal lenses. Teacher must carefully consider their personal beliefs about what mathematics is and about how they look at mathematical pedagogy, content, processes and practices. They must be willing to look deeply at what they say they are doing and what they are actually doing. They must be willing to change. They must be educated about how to be

sensitive to cultural and language differences between them and their students and within the groups of students they work with.

APPENDIX A

SURVEY QUESTIONS

1. Please describe any ways you have benefitted thus far by participating in Project MACIMISE.
2. Please describe any difficulties you have had or are having while participating in Project MACIMISE.
3. Please describe new discoveries and learning you have gained about your home culture while in Project MACIMISE.
4. Please describe new discoveries and learning you have gained about other cultures through Project MACIMISE.
5. Please choose to what extent you are actively engaged in the requirements for the MACIMISE classes thus far. Choices: Very engaged, Engaged, Somewhat engaged, Struggling to be engaged, Not engaged well.
6. To what degree have you found the courses provided in Project MACIMISE useful in supporting you in what you want to focus on in your research? Choices: Very useful, Useful, Somewhat useful, Not very useful, Unsure.
7. Please describe where you are in the MACIMISE process. For example, “I have research questions, and am conducting surveys related to them,” or “I am considering developing curriculum, and these are the obstacles I am facing.” Please just describe what you have done, how you think you will progress in Project MACMISE and any obstacles, challenges, rewards, etc. that you are experiencing.
8. Is there anything else you would like to share?

APPENDIX B

INDIVIDUAL INTERVIEW QUESTIONS

1. Why did you decide to participate in the MACIMISE project? What did you hope to gain?
2. Tell me about your journey thus far in Project MACIMISE.
    a. Have any of your feelings, understanding(s), grown or changed regarding Project MACIMISE since the inception of the project? If so, please tell me how.
    b. Have the courses you've taken influenced and/or changed any of your ways of thinking about research, curriculum development, your home culture and mathematics? If so, please explain how.
3. Now I am going to ask some questions about where you are now in your journey.
    a. Please tell me about your curriculum.
    b. Have you experienced any difficulties? If so, what are they?
    c. How do you envision the future of your curriculum development and implementation?
4. Part of agreeing to participate in this study means that we will have to communicate from a distance.
    a. Describe how best we can communicate in the next two years.
    b. Are there any questions you think you may have in the future that I may plan for?
    c. Are there any ways that I can help you?
5. Is there anything else you would like to share?

APPENDIX C

FINAL FOCUS GROUP INTERVIEW QUESTIONS

1. Thinking about the entire program, is there anything that stands out as most memorable or meaningful for you?

2. Are there any ways you've changed as a result from participating in this program? Do you think differently—about your culture, about mathematics, about education—as a result from participating in this program?

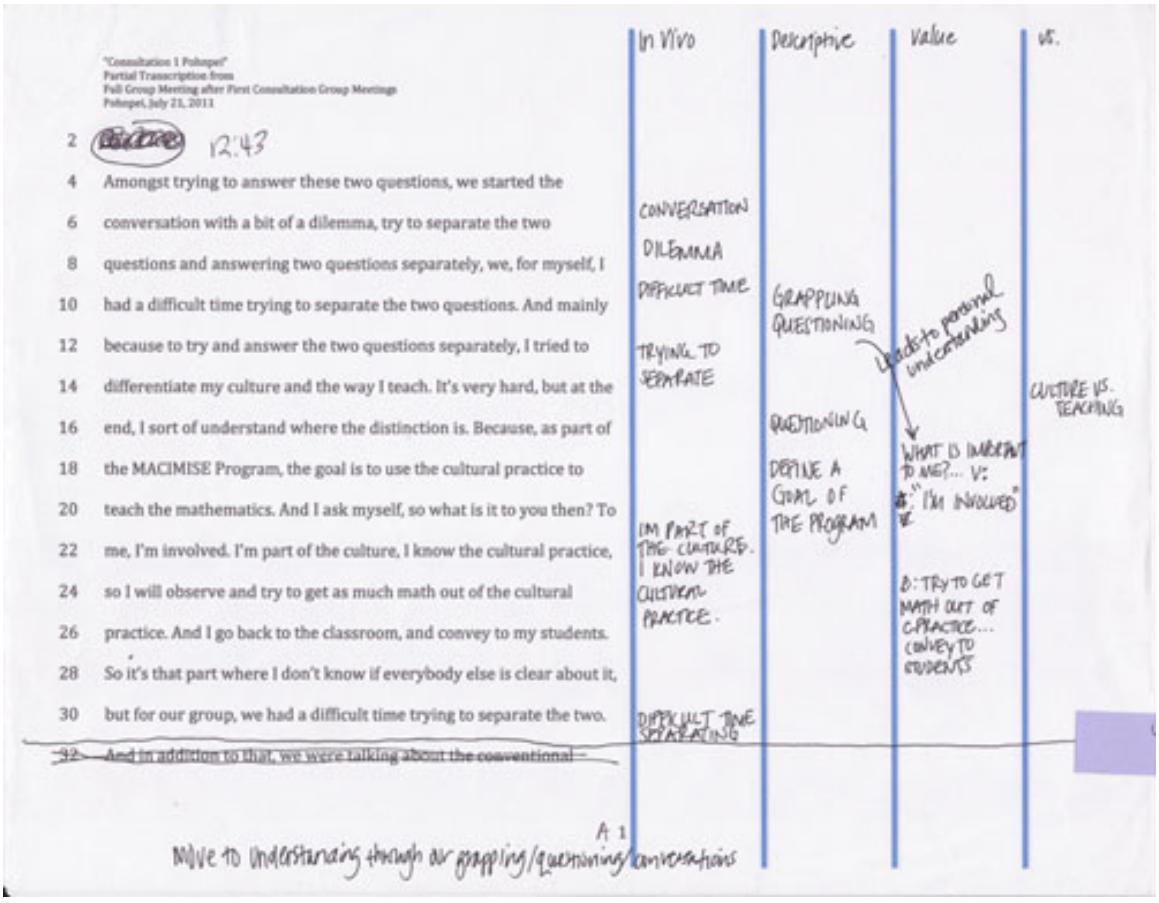
3. What were your personal goals when you entered this program? Did those same goals continue throughout the project? Have you realized those goals?

4. If there were another program like this in the future, would you recommend anything be done differently?

5. Is there anything else you would like to say?

APPENDIX D

FIRST CYCLE CODING SAMPLE



APPENDIX E

QUESTIONS FOR DOCTORAL COMPS

1. Describe what you understand by the term ethnomathematics. Why is it important to the teaching of mathematics? Give two examples of aspects of ethnomathematics from your home island.

2. Indigenous methods of research typically focus on qualitative approaches. Describe which methods you intend to use, explain how these are appropriate to your research plan, and to the context in which you are working.

3. Briefly describe the Common Core mathematical practices. In what ways are these approaches appropriate and in what ways are they not appropriate to the context on your island? Please give reasons, and illustrate your reasons with specific examples.

Your responses to these questions should be word-processed, 12-pt font, 1.25-inch margins, and a maximum of 15 pages per question (or 45 pages in total for all three questions), double-spaced.

Your responses should be emailed as an attachment to Sandy Dawson (dawsona@hawaii.edu) no later than midnight, Sunday, July 1, 2012. He will distribute your responses to the members of your Doctoral Committee.

APPENDIX F

UNIT PLAN TEMPLATE

MACIMISE Unit Plan
Unit Title:
Rationale:

Stage 1—Desired Results				
Goals				
Enduring Understandings		Essential Questions		
Knowledge		Skills		
Common Core Standards addressed				
Stage 2—Assessment Evidence (attach copies of everything you will use)				
Summative Assessment Task		Other Evidence		
Stage 3—Learning Plan (Titles of your lessons)				
Day 1:	Day 2:	Day 3:	Day 4:	Day 5:

MACIMISE Daily Lesson Plan

Title: _____ Lesson # _____

Stage 1—Today's objectives			
Stage 2—Today's formative assessments for learning			
Stage 3—Today's learning strategies (attach copies of all materials you use)			
Introduction			
Time	Teacher Activities	Student Activities	Materials
Activities (step by step details and organization enough for someone else to follow.)			
Time	Teacher Activities	Student Activities	Materials
Conclusion (review: what did we learn today and why does it matter to us)			
Time	Teacher Activities	Student Activities	Materials

APPENDIX G

IRB SUBMISSION FOR FOURTH GRADE UNIT

Finding Our Way: Designing, Implementing and Assessing a Culturally Relevant Unit Engaging 4th Grade Students in Inquiry and the Common Core Standards for Mathematical Practice

Purpose and Objectives of the Research

From August to December 2013, an instructor from the Institute for Teacher Education, University of Hawai‘i at Mānoa, will be working with two teachers (one general education and one special education) who co-teach in their 4th grade classroom at Waiau Elementary School. Their goal is to design, implement and assess a culturally relevant mathematics unit based on *Hōkūle‘a*’s World Wide Voyage through engaging the students in inquiry and the Common Core Standards for Mathematical Practice.

In Planning for Inquiry: It’s Not an Oxymoron (2007), Diane Parker describes a framework for developing curriculum from students’ questions and authentic classroom events. In addition, she presents “general principals and specific strategies for facilitating the type of classroom discourse that can encourage and guide inquiry” (p. 57). Although not specifically focused on mathematics, some aspects of her framework may be useful to incorporate.

Teachers are currently tasked with implementing the Common Core State Standards for Mathematics and the Standards for Mathematical Practice.The latter are: (1) Make sense of problems and perservere in solving them. (2) Reason abstractly and quantititively. (3) Construct viable arguments and critique the reasoning of others. (4) Model with mathematics. (5) Use appropriate tools strategically. (6) Attend to precision. (7) Look for and make use of structure, (8) Look for and express regularity in repeated reasoning.

This qualitative study seeks to answer the questions:

1. By beginning with a cultural context, *Hōkūle‘a*’s World Wide Voyage, and engaging students in personal inquiry, can teachers design learning experiences that engage students in the Common Core Standards and Standards for Mathematical Practice?
2. What do the teachers do and say? What tasks and activities result?
3. How do the teachers go about assessing their students’ level of engagement in these practices?
4. From exploring these questions, can a framework for an inquiry-based, culturally relevant mathematics curriculum be described? Can some general principals and

strategies for implementing and assessing the Common Core Standards for Mathematical Practices result?

Research Design and Methods

Participants

There are three participants in the study: a university elementary mathematics instructor (the principal investigator and a participant-obsever), the general education teacher, and the special education teacher. The three participants have met to discuss this project and are collaborating to plan for it.

Research Activities

Approximately once per week, from August to December 2013, during the 4th grade students' social studies, science and health instructional blocks, the university instructor will lead students' inquiry discussions focused on Hokulea's World Wide Voyage and mini-lessons focusing on mathematical concepts, processes and models that can be used to help students solve the problems that result. All three participants will facilitate individual and small group activities while students are engaged in their inquiries. The classroom teachers may continue activities while the university instructor is not present.

"Educational Curriculum" as part of "Normal Educational Practice"

Currently, teachers are charged with finding ways to implement the Common Core Standards. With more and more time being spent on language arts and mathematics, they struggle to find time to teach all of the subjects they need to. Social studies, science and health are too often neglected or treated superficially. In addition, some of the schoolwide goals at Waiau Elementary School are to engage students in inquiry and enhance and build opportunities for students to engage in authentic STEMS (Science, Technology, Engineering, Mathematics, Social Studies) experiences. By integrating mathematics through using the culturally relevant context of the World Wide Voyage, the teachers will be engaged in their "normal" educational practices of finding time to teach social studies, science and health while also exploring how to effectively implement the Common Core Mathematics Standards and Standards for Mathematical Practice through the process of student inquiry. These activities are those that classroom teachers often do as part of the routine completion of their work. This work includes planning for and implementing lessons, thoughtfully reflecting on practice and discussing work with other educators.

Data Collection

All three participants will keep written journals that include field notes. They will be asked to reflect on the following prompts while engaged in the activities and at least weekly:

1. What are some things treachers said and and did that facilitated student inquiry?
2. What are some things teachers said and did that engaged students in the Common Core Standards for Mathematical Practice?
3. What are some recollections about what students did and said that were evidence of engagement in inquiry?
4. What are some recollections about what student did and said were evidence of engagement in the Common Core Standards for Mathematical Practice?
5. What are some ways students are being assessed on their engagement in and/or attainment of the Common Core Standards and Standards for Mathematical Practices?

In addition to the journals, the three participants will meet weekly for up to an hour to discuss how the unit is progressing and plan for next lessons. The discussion will be focused on the process they are engaged in and will be audiotaped. Recordings will be transcribed with no personal identifiers and will be destroyed once transcribed.

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