CROSS-CULTURAL SCIENCE LEARNING WITH KAREN REFUGEE PARENTS AND KAREN ELEMENTARY STUDENTS IN RESETTLEMENT

by

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ABSTRACT

For refugee students in resettlement in the United States, recognizing culturally-produced knowledge within the context of science learning could legitimate their ways of knowing and position them as stakeholders in the production of scientific knowledge. However, research in science education has been slow to articulate how refugee students' cultural and experiential knowledge impacts their engagement with scientific practices and language specified by the Next Generation Science Standards (NGSS) (Achieve, 2013). This two-phase research with Karen (first-generation refugees from Burma) parents and students explored first the knowledge Karen parents wished their children to retain as they transitioned into education in the U.S., and second built this knowledge into a science afterschool program for 4th and 5th grade Karen and non-Karen students.

Framed by the critical pedagogy of place perspective, this action research explored: 1) what cultural knowledge if any 4th and 5th grade Karen and non-Karen students constructed in a cross-cultural science learning community; and 2) the relationship of that cultural knowledge to how student participants positioned themselves as science learners. Findings from phase one of the research revealed a

cultural counter-narrative constructed by Karen parents in resistance to the military dictatorship in Burma. Findings from phase two indicated that Karen students and non-Karen students constructed a hybrid learning space in which they were able to define their own culturally- responsive approaches to inquiry-based science learning, the NGSS cross-cutting concept of energy, and practices such as constructing scientific explanations. An articulation of students' indigenous knowledge collected through Photovoice was essential to the production of cultural and scientific knowledge within the cross-cultural learning community. Data collected through video recordings indicated that some Karen students leveraged their knowledge of the Karen language to position themselves as agents in science. Signs of emerging agency in science learning indicate that Karen students could develop and use the platform of their own indigenous knowledge to build cultural resilience in education in resettlement.

INDEX WORDS: indigenous knowledge; cultural resilience; Karen refugees; cross-cultural science learning community

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CHAPTER 1

Introduction: Karen Refugees and Science Education

Issues of equity in education for refugee students in resettlement have become more pressing in the United States over the past decade. According to the U.S. State Department, an average of 61,452 refugees per year has been admitted to the U.S since 2005. On a global scale, over 59.5 million people were forcibly displaced from their countries of origin by the end of 2014, an unprecedented number (Migration Policy Institute, 2014). Yet the national learning paradigm in the U.S. has not shifted to accommodate the needs of refugee students, many of whom have had interrupted, little or no formal education. Standardized testing in schools assumes a conceptual command of the English language that refugee students in resettlement struggle to achieve in their first five years of living in the United States (Cummins, 2008). Similarly, the national science standards for performance, language and practices outlined by the Next Generation Science Standards (NGSS, Achieve, 2013) call for students to put on the mindset of scientists and engage in critical practices such as argumentation and constructing scientific explanations based on evidence. Refugee students may not have the academic or social confidence to engage in these practices in a meaningful way. Many refugee families resettling in the U.S. are escaping the trauma of war and have cultivated a climate of invisibility for survival; consequently, the confidence required for open debate and critical thinking might be difficult for refugee students to acquire. Research on the compatibility of scientific inquiry and the cultural patterns of discourse and behavior of

students emerging from non-dominant learning paradigms has indicated that often the confidence to position themselves as agents in science learning is missing (Lee, 2002). Within science education literature, little work has been done on how to integrate refugee students into science learning in a way that allows them to engage with scientific practices as agents with decision-making power.

For the past four years, I have worked with first-generation Karen refugee families who originate from Burma. Refugees from Burma constituted the highest percentage of refugees resettling in the United States in 2015: 18,386 (26.3% of the total number of 69,933). Many Karen families have lived in refugee camps on the Thai-Burma border for ten to twenty years, without access to employment or higher education, unable to return to their villages for fear of military attack. Refugees have been defined by the United Nations High Commissioner for Refugees (UNHCR, www.unhcr.org) as those people who have been involuntarily displaced from their countries of origin due to the threat of violence based on religion, ethnicity, nationality or political association. Politically, refugees face three options: repatriation to their country of origin; resettlement to a third country; or integration into the country that hosts the refugee camps. Only one percent of refugees achieve resettlement in a given year (McCarthy & Vickers, 2012). Refugees who succeed in attaining resettlement through UNHCR in an economically-developed country face a new set of obstacles. Economic and social struggles to integrate into their new country are accentuated by a language barrier. Successful pedagogical models for the children of refugee families are limited. In a study of middle-school aged Sudanese, Eritrean, Burundian, and Rwandian refugees in Australian schools, Dooley (2012, p. 5) found that these students experienced forms of

"everyday humiliation" that made school unbearable. Dooley attributed this condition to the lack of respect shown to the students by teachers and their peers, a lack of "symbolic capital" that resulted from the status knowledge brings in an academic community of practice (p. 7). In one Karen population resettled in the urban north-east U.S., twenty children were enrolled in various public schools, the majority in a middle school with over 1200 students (Kenny & Lockwood-Kenny, 2011). The majority of the students were Hispanic and African-American; Asian students made up less than 1% of the school population. Karen students were placed in a Language Transition Support Services (LTSS) class with mostly Hispanic students and teachers who spoke English or Spanish. Many of the Karen students were significantly older than their classmates. Even though teachers welcomed the refugee students with enthusiasm, this enthusiasm quickly waned, and the Karen students came to be seen as oddities in the school community. Many left school to begin factory work alongside their parents, and few children stayed in school through the secondary level.

Pedagogies and instructional strategies for incorporating diverse cultural and experiential knowledge into increasingly multilingual and multicultural classrooms in the U.S. have met with limited success. Science educators working with culturally-diverse students have used teacher-mediated instructional strategies such as instructional congruence (Lee & Fradd, 2002) and funds of knowledge (González, Moll & Amanti, 2005) to infuse the science classroom with culturally-appropriate ways of knowing. Instructional congruence links scientific discourse and inquiry with the experiential and cultural knowledge of non-mainstream elementary students, but relies upon the teacher's ability to identify the experiential and cultural knowledge of the students, and connect

these streams of knowledge with scientific knowledge and practices (Luykx & Lee, 2007). Similarly, the funds of knowledge approach filters the cultural knowledge of diverse families through the cultural lenses of teachers, the majority of whom belong to the dominant culture in the U.S. (Cochran-Smith & Zeichner, 2010). When teachers have roots in diverse cultures and languages themselves, both of these strategies have succeeded in building bridges of cultural understanding for a diverse student body and enabling them to develop self-identities as science learners (Meyer & Crawford, 2015). However, neither of these multicultural instructional strategies – funds of knowledge or instructional congruence – addresses the power issues implicit in a science learning environment in which teachers from the dominant culture interpret the cultural knowledge of their students and decide which knowledge has legitimacy in the science classroom. Critics have traced the ineffectiveness of culturally-relevant pedagogy to teachers who did not share a cultural background with their students or who have not had experiences designed to shift their science teaching and learning paradigm to accommodate the needs of a diverse student body (Gay, 2002; Sleeter, 2012). Asset pedagogies such as culturally relevant pedagogy no longer capture the full extent of the hybrid ways of knowing and being that culturally diverse students bring to the classroom; a more culturally permeable environment for learning is needed (Paris & Alim, 2014). Similarly, in a recent critique of the Next Generation Science Standards (NGSS, Achieve, 2013), Rodriguez (2015) called for *a new dimension of engagement, equity and diversity* for the national science standards that shifts educators' understanding of culturally relevant pedagogy away from its current categorization as an addendum to the main landscape of science learning and teaching toward a full transformation of that landscape.

Within this demonstrated need for pedagogical models and curriculum development that embrace the diverse cultures of students, this research looks at science education literature that seeks to reconcile epistemologies of non-dominant populations with the use and production of knowledge in the mainstream science classroom. Challenging the assumptions of legitimate cultural knowledge in the mainstream classroom has precipitated discussions of how indigenous epistemologies can contribute to meaning-making in science education. One study in Malawi found that an alternative space for science learning was critical for negotiating the gradual decolonization of science pedagogy and incorporating knowledge from the elders of the community about sustainable agricultural practices into science education (Glasson, Mhango, Phiri, & Lanier, 2010). Malawian teachers who had been trained in Eurocentric science concepts and who taught exclusively in English resisted the idea of adapting their pedagogy to a more culturally appropriate learning space that included the language and embodied scientific knowledge of local communities. Decolonization occurred through the introduction of an alternative approach to science education through sustainability science. In another example, a First Nation scholar who chose ethnobotany over one of the more mainstream science disciplines for his field of study was censured by Western scholars for making a poor choice; for him, it was the difference between studying embodied science knowledge contextualized and made relevant by own cultural community, and choosing disembodied knowledge (Chinn, 2009). For real world problems such as climate change, indigenous knowledge on sustainable practices of conservation that preserve a delicate balance between social and ecological systems has connected Hawaiian students to scientific ways of knowing more intimately than

decontextualized Western scientific knowledge could have (Chinn, 2010). Lori Hammond's (2001) collaboration with a Mien community in a summer institute for pre-service and in-service teachers demonstrated the advantages for refugee students and their families of integrating cultural and scientific knowledge. Mien parents used their cultural knowledge to build a traditional garden house on public school grounds. By employing a multi-science approach, Hammond was able to incorporate indigenous science into Western science to create a "dialogic learning community in which various voices were heard" (2001, p. 987). Once engaged for their expert knowledge, Mien parents began to participate more in the science learning of their children.

Research Questions

The purpose of this research study was two-fold: 1) to allow Karen parents in a small rural community to represent their own culture in a public forum by identifying what cultural knowledge they would like their children to retain as they transition into the U.S. educational system; and 2) to explore how that knowledge could be leveraged within a cross-cultural learning community for 4th and 5th grade students to advance Karen students in science learning. To facilitate this research, I partnered with Karen parents to design curriculum for and teach in an afterschool science and culture program at a local elementary school in which Karen students and parents were a minority population. Through an action research design, and qualitative methods such as Photovoice and narrative portraits, this research sought to create an emancipatory educational space for science learning, in which Karen parents and students could articulate their own cultural identities. Karen parents adopted a discourse of poverty of knowledge in the area of science when I first introduced the project to them and asked for their collaboration.

They viewed their knowledge of horticultural and self-sustaining farming practices as inferior to the science and technology of the U.S. A deficit model in parent engagement assumes the role of parents to be passive participants rather than active agents with decision-making power (Calabrese Barton, Drake, Perez, St. Louis, & George, 2004). Therefore, it was important to frame this research around the concept of resilience and situate it within an emancipatory paradigm within which refugee parents were actors choosing their own cultural identity and making decisions about what cultural knowledge was important for the science education of their children. For students from first generation refugee families who have experienced the trauma of violence and long-term displacement, the identification and retention of their indigenous knowledge systems could be critical to re-building their cultural identity in their host country as well as building their identity as science learners. The following questions guided this study:

1) How does the construction of a cross-cultural learning community that privileges Karen cultural knowledge affect the science learning of Karen student participants?

2) How does the presence of Karen cultural knowledge represented by a Karen co-teacher and the Karen language affect how students position themselves within the learning community?

Theoretical framework: Critical Pedagogy of Place

A critical pedagogy of place theoretical framework focused my attention on the role of education as transformative medium through which participants engage with critical analysis of the world around them (Gruenewald, 2003). Critical pedagogy of place ties the theoretical threads of place-based education, critical pedagogy, and an agenda for ecological sustainability into a versatile tool that addresses relationships of power and domination between human communities, and between social and ecological

systems. Two objectives for education characterize this framework: decolonization and re-inhabitation. Whereas the research with parents was conducted in the homes of Karen families and at community sites where Karen families gathered, the research with students took place at the local elementary school, in which the Karen students were a cultural and linguistic minority (8%). Physical and cultural decolonization of the learning spaces used in this research was needed to disrupt the assumption that science knowledge could only be produced and used within the dominant culture. Within the dominant culture, students who do not meet the cultural norm can be trapped within disempowered spaces if their ways of producing knowledge are not recognized as legitimate (Upadhyay, 2009). Therefore, it was important to re-inhabit our learning space with cultural ways of knowing that challenged the existing cultural terrain and allowed students and teachers to generate their own legitimate cultural knowledge.

Within this framework, embodied knowledge was a critical construct that encompassed issues of language, identity and discourse. Critical pedagogy of place has been referred to as embodied learning, a counter-narrative to homogenized education that can be dehumanizing for children caught outside the mainstream. It shifts the paradigm of learning away from the institutionalized construct of school learning manifested by decontextualized knowledge, and situates it within the students' own cultural and experiential spaces (McInerney, Smyth & Down, 2011). In this way, education becomes a medium for individual and social transformation through the process of critical consciousness (Freire, 1970). Students engage in radical ways with their immediate sociopolitical environment, challenging the assumptions of the dominant culture about who they are and how they learn in addition to the discourses and images projected by

other people onto their lives. Their identities as science learners hinge on how they shape a trajectory of engagement with science: "Science involves not only how one comes to understand the natural world and how that knowledge/practice is situated historically, but also the continuous re-creation of scientific practices and ideas within the systems that support them" (Calabrese Barton & Brickhouse, 2006, p. 223). In the context of embodied science, the use and production of scientific knowledge is not acultural, but deeply contextualized.

This understanding of science learning as embodied engagement with the world entails an enlivened process of students generating new knowledge and leveraging existing knowledge to develop an identity as science learners. In her work on feminist epistemology for science education, Brickhouse (2001) suggested the process of learning in this perspective was not about the tacit absorption of scientific knowledge, but rather focused on how science learners negotiated their self-identity in relation to the world: "In other words, in order to understand learning in science, we need to know much more than whether students have acquired particular scientific understandings. We need to know how students engage in science and how this is related to who they are and who they want to be" (Brickhouse, 2001, p.286). Tan and Barton (2012) used Freire's definition of education as a transformative space to inform their understanding of the process of empowerment: how students can challenge and re-create their understandings of self and the world. "Critical science and math literacy is built on three main ideas: transformation of discourses and practices, transformation of identities, and transformation of spaces for learning/doing science" (p.40). From this position, they argued that learning is inextricably tied to students' self-knowledge and their construction

of self-identity in science: "…critical engagement with science and math also calls into question who can do science and math and what it means to author and challenge scientific and mathematical authority. The subjectivities that youth bring to science and math shape how they seek to access the domain and the roles they take up. When the learning community fails to legitimize the identities that one brings, then opportunities for critical engagement are shut down" (p.41).

For refugee students, issues of "belonging" can hinge on the identity and discourses they are able to access during the process of integration into traditional settings such as the local school (Strang & Ager, 2010). Gee (2001) linked social identity with the discourses individuals access in social settings and through interaction with others. The power to use discourse to shape one's own identity or to have a hand in how a group identifies another in a social group has a direct bearing on how well a student integrates into a classroom setting. Thus language can be a powerful tool in the determination of a refugee student's integration into the science classroom, in both the discourses adopted by the science teacher, and the discourses of cultural knowledge the teacher allows students to access in science learning. Discourse that emerges from institutionalized authority can sometimes reflect a homogenization of cultural knowledge that excludes students who are considered "other" by the dominant cultural group. Within the critical pedagogy of place perspective, I sought to interrogate the physical and cultural spaces for science learning, de-settling the cultural terrain of the production and use of scientific knowledge, with attention to how students transformed, or re-inhabited, those spaces with self-generated learning identities.

In addition, situating this research within the concept of *place* recognized the inextricable relationship of involuntarily displaced people to the physical place where they live, work and raise their children. For indigenous communities such as the Karen, some of whom have been involuntarily displaced for decades, place could function as a vital connection to embodied knowledge. Castagno and Brayboy (2008) have defined indigenous populations as "those who have inhabited lands before colonization or annexation; have maintained distinct, nuanced cultural and social organizing principles; and claim a nationhood status" (p. 943). A legitimate paradigm of indigenous knowledge reflects a multi-locality and multi-vocality (Rodman, 1992) contingent upon a dynamic flow of knowledge production situated in history and the encounters history brings. It is a rare indigenous community that has not come into contact with economic and social forces that originate from outside the bounds of the traditional spaces where knowledge has been produced in the past or through interaction with neighboring communities. In the age of globalization, the production of local knowledge is not limited to interrelationship with the environment but widens to include historical encounters with harbingers of development from outside sources that are not always unwelcome (Ellis & West, 2004).

This understanding of the hybrid multi-locality nature of indigenous knowledge can be reconciled with a critical pedagogy of place theoretical framework through an understanding of knowledge as embodied and situated within a community of practice (Lim, Tan & Calabrese Barton, 2013). *Place* in a globalized world of displaced peoples becomes socially constructed around communities, activities, and the meaning that binds people and activities together. To reduce a historically-situated, socially-constructed

landscape to a reified geographical location disembodies locality in the same way that knowledge can be disembodied by severing it from its socio-cultural political context. Multi-locality, by contrast, is "predicated on connections, on the interacting presence of different places and different voices in various geographical, anthropological (cultural), and historical contexts" (Rodman, 1992, p. 647). In his work on indigenous science, Gregory Cajete (2000) described the reciprocal relationship of indigenous people with nature as "embodied relationships that must be honored. Through the seeking, making, sharing, and celebrating of these natural relationships, they came to perceive themselves as living in a sea of relationships. In each place they lived, they learned the subtle, but all important, language of relationship" (p.178). This perspective of *place* encompasses an ethical and spiritual positionality in relation to science that would be difficult to replicate in the mainstream classroom apart from an understanding of the importance of embodied knowledge for shaping a hybrid cultural space for learning.

Organization of the Dissertation

In Chapter 2, I review the literature on refugee students and education. Since literature on refugee students and science education was not available, I situated this research within the debate in science education on which knowledge is considered legitimate and how the cultural terrain of science knowledge can be made more porous to allow in multiple epistemologies. As stated above, my theoretical framework enjoins a critical approach to how learning spaces are constructed and how meaning is constructed within those spaces. I looked to alternative non-dominant sources for the emergence of legitimate knowledge, challenging the assumptions about knowledge production and use implicit in the dominant culture of institutionalized education in the United States.

Connecting this work on education and refugees with current research in indigenous epistemology, I argue, is a missing link that has not been explored fully in research on displaced populations and science education. Chapter 3 contains a review of the methodologies used in this action research, with a focus on the suitability of Photovoice for research with vulnerable populations. I also describe in rich detail the afterschool program that served as a vehicle for this research with attention to instructional strategy and curriculum design. This chapter ends with a section on reflexivity and my subjectivity statement. Chapter 4 outlines the findings from both phases of this research, detailing the counter-narrative that emerged from analysis of the Karen parents' visual narratives and relating that to the narratives that emerged from the afterschool program with Karen students. In Chapter 5, I discuss how these findings relate back to my original research questions and suggest ways they tie into and contribute to research in the field of science education. In addition, I discuss the implications of this research with Karen students and parents for science teaching in the mainstream elementary classroom and for science teacher education. Finally, I discuss directions for future study that have developed from this research.

CHAPTER 2

Literature: Culturally Diverse Students and Scientific Knowledge

In this chapter, I situate my research within two important arenas of discussion: 1) refugee students and education; and 2) the academic debate in science education on the production and practice of scientific knowledge. In order to adequately address the question "What is the cultural platform from which scientific knowledge is produced and practiced in science learning?" I have to look at the question "What is legitimate scientific knowledge in the science classroom?" Therefore, the second part of this chapter focuses on two different streams of knowledge that inform the epistemology of science in culturally diverse classrooms: Indigenous Knowledge (IK or TEK) and Western Modern Science (WMS). These categories of knowledge emerge from a history of British and American colonization that is too extensive to cover here. However, an understanding of the colonization of knowledge is essential to my theoretical framework; decolonization cannot occur in a vacuum of power. Smith (1999) descried the invisible platform of culture underlying the production of legitimate knowledge:

> "The globalization of knowledge and Western culture constantly reaffirms the West's view of itself as the centre of legitimate knowledge, the arbiter of what counts as knowledge and the source of 'civilized' knowledge. This form of global knowledge is generally referred to as 'universal' knowledge, available to all and not really 'owned' by anyone, that is, until non-Western scholars make claims to it. When claims like this are made history is revised (again) so that the story of civilization remains the story of the West" (p. 63).

This research assumes that the production of knowledge stems from a cultural base. One task of this chapter is to challenge the assumption that there is only one legitimate

cultural base for science learning. Finally, using critical pedagogy of place as a framework, I review various strategies in science education literature focused on integrating students from diverse cultures into the epistemology of science.

Refugee Students Transitioning into Western Education

The struggle to maintain allegiance to a cultural identity remains one of the most prominent obstacles refugee families face. "The unmasking of the sociopolitical role of whiteness and of its instrumentality in furthering Eurocentrism should lead to deeper understanding of the pedagogies of de-culturalization imposed by Western schools and the devastating impact of this imposition, not only on indigenous students but also on other subjugated ethnic minorities" (Hickling-Hudson & Ahlquist, 2003, p.83). Research indicates attempts to overcome the process of de-culturalization in schools that accepted refugee students consistently involved families and communities in collaborative projects intended to scaffold learning in formal and informal settings. Moreover, they endorsed intercultural multi-lingual learning environments embodied by the history, culture and home languages of students represented in the classroom.

McBrien (2005) stressed the difference in learning styles as a critical source of cultural dissonance for refugee students transitioning into western schools. The student who learns in a field-dependent style might prefer to work with groups, needs outside encouragement, and promotes the well-being of the group above that of the individual. This learning style is prevalent in students with cultural roots in Buddhism, and could apply to Karen students. The alternative learning style is field-independent, which promotes individual achievement above that of the group, and caters to self-motivated, self-directed learning. In Western schools, teachers associated field-independent learning

with higher intelligence. McBrien suggested that this cultural obstacle could be overcome with more communication between schools and ethnic communities, and between refugee parents and teachers. One pre-service teacher education program paired teachers with refugee and immigrant students for tutoring; pre-service teachers read books with the children and then discussed the readings with the parents. Refugee parents embraced this type of cooperative learning. Bilingual students who had cultural capital in their home culture and in their host culture achieved higher scores on tests, had lower levels of depression, higher self-esteem, and higher career and upper-education goals. This approach led to less friction with parents rooted in the culture of their home country during the acculturation process, another obstacle that refugee students often faced, and facilitated healing and developmental growth as well as academic achievement (Isik-Ercan, 2011).

McBrien and Ford (2012) called attention to a culturally-appropriate liaison service between parents and schools developed by a private refugee aid agency in the southeastern United States. The agency, Refugee Family Services (RFS), sponsored after-school tutoring, a summer camp, individual tutoring, at-risk services, English lessons for adults, job counseling, cultural information for the community and refugee families, and their centerpiece program, a cultural liaison staff that bridged the cultural understanding gap between school administration, teachers and refugee parents. All of the liaison staff were women, culturally and/or nationally matched to their clients, who spoke the native language of their clients. As of 2008, this program could be found in forty-three schools across a ten-mile radius, and twenty-four schools more than ten miles distant. The liaison staff as a whole spoke more than twenty-five languages in addition to

English. Results showed that teachers who worked with RFS liaison staff were more likely to report increased knowledge of the refugee culture, engage in intentional efforts to make the school environment more refugee-friendly, work more successfully with refugee parents, and have high expectations for advanced education through college or vocational schools for their refugee students. Another study focused on teacher-parent relationships between school representatives in Wisconsin public schools and a local Hmong population; researchers found that the creation of a parent liaison position was essential to bridging the cultural and language gaps for successful communication and partnership (Rah, Choi, & Nguyen, 2010). The effort of developing outreach programs to facilitate the integration of refugee parents into the schools' community of practice proved critical to the academic and social success of refugee children.

Transmigrant communities such as the Hmong people who have lived in the United States for several generations have leveraged community knowledge to construct a counter-narrative for education that privileges their own ways of knowing. Bhaskar Upadhyay (2009) explored how a Hmong teacher used her own experience of marginalization in mainstream science learning to inspire a more inclusive approach in her classroom. She introduced Hmong students' gardening experiences into the classroom as a way to build on their cultural funds of knowledge, and created a climate of reciprocity that would engage Hmong parents in science learning. Hmong parents responded by supporting the students' science learning, and taking a more active role in communicating with the teacher, particularly since they could speak in their own native language. This was radically different from the Hmong teacher's own experience in the science classroom, in which the teacher did not use any examples from Hmong

communities to help students understand scientific concepts, a choice that marginalized Hmong students. In the study, she stated that she grew up believing that her Hmong culture was an obstacle to science learning.

Another Hmong community that had multiple encounters with racism and deficit teaching in schools constructed a counter-narrative composed of essentialist cultural knowledge in an effort to carve out socio-political representation in a hostile environment (Ngo 2013). Even though they could have chosen the discourse of hybridity to articulate their cultural identity, the community leaders employed an essentialist discourse to push back against the pressure to assimilate. As second generation immigrants, this Hmong community responded to what they viewed as a direct relationship between a higher rate of academic failure in Hmong-American young people to the loss of identity that resulted when students severed connection with their home language and culture. Community leaders determined that only a narrative stressing a reified view of their culture was strong enough to combat the "otherness" their children were experiencing in schools: "School omission of the histories and experiences of Asian Americans has implications for the construction of identities – particularly citizenship and belonging" (Ngo 2013, p. 972). In addition, they looked for an embodied representation of their culture in the schools to amend this identity crisis; in other words, their cultural knowledge could only be represented adequately by educators from within the Hmong community. Their political battle for representation in the school system pushed back against the assimilationist discourse they encountered in Western education, in the same way that Native Americans have pushed back against assimilation in order to define their own cultural discourses in the schools (e.g. Cajete, 2000; Deyhle, 2009; Barnhardt &

Kawagley, 2011). The lack of literature in pedagogical and social fields focusing on Karen resettlement in the United States suggests that they have yet to build social and political discourses for themselves, either in engagement with the public school system or in other public arenas. In the following section, I examine existing literature on Karen refugee families and education.

Karen Refugees: Education in Resettlement

Since 2005, Thailand has allowed the UNHCR to appeal to Western countries such as the U.S., Canada and Australia for resettlement options. Jack Dunford, the Executive Director of the Thailand-Burma Border Consortium, recorded his impressions of Karen resettlement in America after a visit in 2008:

> *One of the biggest challenges for the refugees is language and since I normally meet with the leaders when I visit the camps and see English classes going on in the schools, I was surprised at just how weak the Karen are in English. This of course is a major barrier to getting work and being able to function in their communities. We heard stories of people being literally house-bound because they were afraid to go out and stories of people who had gone out and wandered for days because they didn't know their address or how to ask for help….Dreams of higher education for older kids though seemed difficult to attain. Even if they can get funding/ scholarships, there is tremendous pressure to be bread-winners to help their families get established. One very bright student said "I want to go to college, get qualified and go back to the border to work for TBBC. But I am too busy helping all the Karen here and have no time to study." Another very impressive young man had been in the States for a decade but was still two years off graduating because he had been factory shift working to support his family* (Dunford, 2008, pp. 2-3).

Many Karen families applied for resettlement in the United States or Australia with the hope of gaining higher education for themselves or their children. Worland and Darlington (2011) conducted two case studies with Karen refugees from 2007 to 2008, one in the mega-camp Mae La, and the second with resettled Karen people in Australia. Their study focused on the impact of violence on the identity of displaced Christian

Karen. They hypothesized that a successful transition depended upon social capital, or the support networks of family, friends, and host societies. Focus group participants in Australia cited the lack of English as the major challenge to resettlement. Most were trying to complete a certificate of study at TAFE, Technical and Further Education, the largest vocational education and training provider in Australia. Worland and Darlington found that education in the camps had not prepared the Karen for learning English in the Western style of teaching. Those in resettlement planned to return to the camps to share the benefit of their higher education with the Karen people there.

Karen community counter-narratives provided a source of cultural identity in resettlement in Australia. One study contrasted community narratives of suffering and hope to the individual narratives most commonly found in the mental health literature on refugees and resettlement: "The narrowly focused trauma lens has helped underpin stereotypical understandings of culturally diverse people from refugee backgrounds into a singular pathologized needy identity bereft of resilient and self-determining capacity" (Brough, Schweitzer, Shakespeare-Finch, Vromans, & King, 2013, p. 210). The authors proposed an alternative approach that linked the "micro" of the individual to the "macro" of their larger socio-political environment for the purpose of understanding the social narrative of a refugee community. As many of the refugees shared an experience of trauma and violence that most people in their host country could not relate to, it became important to construct a social narrative of hope that could act as a counter-narrative to the suffering. As with the collective suffering people experienced at the hands of the Burmese military and in the camps, the hope they experienced became inextricably intertwined with the common goal of achieving freedom from political oppression for all

of their people. As a community, their focus was not on the success of individual refugee families who achieved resettlement, but on the families left behind in the camps and across the border in Burma. The authors situated this social narrative within a framework of resilience in an effort to "de-pathologize" the trauma experienced by individuals (p. 210). In their study, when they asked individuals to make meaning of their suffering in Burma, most interpreted the question through a "macro" lens and spoke about the need for socio-political change in Burma so that all people could live in freedom and dignity.

In Fort Wayne, Indiana, the Burmese community leaders initiated an outreach program for parents called the New Immigrant Literacy Program in 2003 that offered tutoring for students and community education programs for parents (Isik-Ercan, 2012). Program directors collaborated with Indiana University – Purdue University Fort Wayne (IPFW) and recruited university students for volunteers. Even though most jobs for the men were located outside Indiana in meat factories, the refugee community provided essential social stability for the children, and functioned as an extended family unit. Integration for the children into the school system proved elusive, however, as children and parents faced language and cultural barriers. Even though early childhood education could jumpstart social belonging and integration into the western learning community of practice, Burmese parents could rarely afford private pre-school, and bi-lingual options were not available. The author of this study advocates for the creation of early education opportunities including after-school programs and weekend programs situated in Burmese cultural community contexts.

This brief look at refugee education in resettlement in the U.S. and other countries which practice a predominantly Western style of education has brought to the foreground

both the obstacles that refugee students in general and Karen students in particular face in the process of integrating into their host countries and the creative strategies educators have advanced to institute a more equitable environment for culturally-marginalized students. By finding ways to re-situate refugee students within slices of their home culture inside the school environment, educators have worked to create space for learning that enables students to accumulate symbolic capital in the classroom (Dooley, 2012).

A Definition of Culture

An understanding of *culture* is essential to the discussion of knowledge that follows. Anthropologist Franz Boas (1858-1942) is credited with orchestrating a paradigm shift away from a colonial understanding of culture as a mechanism used to define an evolutionary hierarchy with European men at the top, to a critical understanding of the impact of culture on human development, and the unique relationship that entails. His approach to gathering ethnographic data in the field, historical particularism, entailed a cultural immersion experience in which the researcher learned the language and particularities of a specific culture through living with the people they were studying over an extended period of time. This approach challenged the assumptions of social evolutionists at the turn of the twentieth century that all cultures developed along the same pattern. Boas turned scholars' attention to the unique historical situation of each people, claiming that culture emerged more from this venue than from universal patterns of evolution.

In education, at the turn of the twenty-first century, the understanding of culture also experienced a paradigm shift, from an association of children marginalized by poverty or language barriers with a cultural deficit model, to a postmodernist model

inspired by globalization of the hybridity of culture. Eisenhart (2001) challenged the notion that school culture can be defined with enough clarity to distinguish any borders at all. Since social groups no longer adhere to a single, uniform set of cultural norms, and indeed exist within the framework of a constantly evolving globalization, distinct cultural bodies have permeable boundaries. Individuals may choose to adopt the discourses and mores of a particular identity group for a period of time, and then move to another identity group as their circumstances change. Or, as Jan Nespor (1997) suggested, individuals appropriate funds of knowledge associated with activities or social groups as they move in and out of various spaces over time. Individual students can choose symbols, discourses, and identities to shape their own self-representation to meet pre-determined goals. Eisenhart concluded that the concept of culture and cultural identity seen through the lens of postmodernism and globalization no longer had a place in objective reality; rather, it was subject to multiple perspectives, multiple sites, and multiple discourses. Therefore students' understanding of what constitutes cultural knowledge and, moreover, what constitutes scientific knowledge determined how they shaped their cultural and science learning identities.

For this research study, it was important to define terms such as "culture" in a way that did not make assumptions about the choices this community would make in shaping their cultural identity. Therefore, culture was defined within the context of the funds of knowledge approach as a hybrid space of blended knowledge and values, with the expectation that this definition would remain fluid and subject to the community's self-constructed narrative (González, et al, 2005). The definition of culture as a static body of knowledge limited to a particular people living in a specific location could not

apply to communities that have been subject to long-term displacement. Students who have had to construct their cultural identity with fluid boundaries, subject to multiple perspectives, discourses, and sources of knowledge, may have more social and cultural confidence to access rigorous science concepts. Likewise, parents who develop the social and cultural capital (Bourdieu 1977) to redefine their cultural identity from multiple perspectives and discourses are more likely to "author" their own interactive resilient spaces within the formal and informal science education of their children (Calabrese Barton, et al, 2004).

Framing Knowledge within Social-Ecological Resilience

A model of social-ecological resilience frames the understanding of human interaction with the environment as a dynamic process subject to constant change. Rather than assuming a system is stable and self-regulating, always striving to exist in a state of equilibrium, the resilience perspective assumes that a system is constantly adapting to change. Surprise, not stability, is the order of the day. The ability of a social-ecological system to absorb disturbance and retain essential functionality is a measure of its resilience. Resilience can also be a way to look at a system's capacity for renewal in the face of total upheaval (Folke, 2006). For example, to achieve a sustainable level of production, an ecosystem practices an economy of energy designed to use natural energy sources to develop new growth without wasting nutrients. Ultimately, this process returns energy to the system so that a dynamic flow of "natural capital" (defined as "stocks of resources generated by natural biogeochemical processes and solar energy that yield useful flows of services and amenities into the future") is maintained (Izac & Sanchez, 2001, p. 9). This process relies upon sentinels of slow-moving evolution and adaptation

such as mature mangrove trees along a tropical coastline or the build-up of rich organic matter in the soil. These sentinels interact in nested cycles with agents of sudden or rapid processes of change engendered by natural or anthropogenic disturbance to minimize their impact (Walker and Salt 2006). Social-ecological resilience is the measure of disturbance a system will tolerate before the set of processes defined by the slow-moving sentinels that have sustained the functionality of the system shifts to allow the institution of a new regime (Folke, Carpenter, Walker, Scheffer, Elmqvist, Gunderson and Holling 2004). The popular belief that ecosystems can absorb any amount of change and rebound into the same functioning equilibrium is misleading; pressure applied to natural systems by disturbance can result in the extinction of species that do not adapt quickly enough (Nelson, Adger and Brown 2007).

Social-ecological resilience as a conceptual framework allowed me to apply this same paradigm of sustainability and adaptability to indigenous people. Nancy Turner and colleagues (2008) identified eight types of invisible losses that indigenous communities can sustain that result in a loss of resilience: cultural/lifestyle losses; loss of identity; health losses; knowledge losses; loss of self-determination and influence; emotional and psychological losses; loss of order in the world; and indirect or direct economic losses. Their work with indigenous communities facing the loss of their land and resources could also apply to refugee communities that have faced tangible and intangible losses through decades of violence and internment (Turner, Gregory, Brooks, Failing and Satterfield 2008). Turner equated the disruption of cultural stability to the ecological damage of climate change; without attention to restoring the system, valuable resources that are critical to functionality could be lost (2008, p.4). Damage to the cultural integrity of an

indigenous community could result in the erosion of social infrastructure and cultural practices that root individuals in meaningful activities and values. To restore resilience, the authors recommended six processes: focusing on what matters to the people who have been directly and indirectly affected; describing what matters in meaningful ways; making a place for these concerns in decision-making; evaluating future losses and gains from a historical baseline; recognizing culturally derived values as relevant; and creating better alternatives for decision-making in the future.

Using resilience as a conceptual framework in this research served a dual purpose: 1) to situate this work within the ecological cycle of renewal and adaptation that individual species or communities must have to survive disturbance; and 2) to situate this work within the critical impetus to recognize the confluence of knowledge streams that indigenous people bring to science education. Although their cultural knowledge was tied to sustainable land management practices in Karen State, Burma, resettlement in the United States may shape their knowledge in unpredictable ways. A focus on resilience prohibits to some extent the categorization of Karen knowledge. This model assumes that their knowledge system is undergoing constant change as they adapt to a new environment. Key characteristics that acted as sentinels to secure the cultural integrity of this Karen community in the face of violence and war subsequently provided a foundation of shared meaning in the early years of resettlement. In the same way that keystone species sustain the functionality of an ecological system, keystone cultural characteristics may prove to be the lynchpin for the collection of long-term social infrastructure and cultural capital that can sustain a displaced community (Aldrich and Meyer 2014).

Science Education: Defining Knowledge in Science Learning

Researchers working with an equity agenda have challenged the idea that any form of knowledge production and transmission is acultural: The processes of learning and teaching science are deeply embedded in cultural knowledge, even if that cultural knowledge is implicit rather than explicit (Bang & Medin, 2010).

> "For some purposes it is tempting to think of science as a culture unto itself reflecting scientific methods for establishing knowledge. Thus, to become a scientist is to adopt the culture of science. Although this perspective does identify some communities associated with consensual scientific practices, it would be a serious error to make the inference that scientists shed their own cultures when they enter through the doors of science" (Medin & Bang, 2014, p. 13622).

Based on the assumption that Western scientific knowledge has been implicitly embedded in Western cultural knowledge through instruction and curriculum, unless that cultural knowledge has been identified and challenged, this research looks at the tension that developed between scientific knowledge and other forms of knowledge, and attempts to define the role of culture in science learning. In addition, this research extends a critical lens to an examination of the epistemology of science, with attention to the colonization/decolonization of knowledge in this context. Glasson, et al. (2010) determined that science instruction and curriculum in Malawi had to be decolonized first so that local indigenous perspectives and understanding of science could be legitimated in an African classroom. Teachers and students needed to experience a shift in their learning paradigm so that a new perspective, one that included local ways of knowing, could emerge. In the same way, attempts to decolonize Western classrooms that host students from multiple diverse cultures have struggled to decolonize the epistemology of students and teachers who implicitly adopt Western culture as the foundation for science learning in the United States.

Western Modern Science

Debates about the nature of science knowledge, how it is produced, constructed, or discovered, and how that knowledge is developed and propagated in our learning institutions, have engaged scholars throughout history. The fear of blurring or even losing the line that separates science from pseudo-science has roots in the battles waged by scientists such as Copernicus, Galileo, Kepler, and Charles Darwin against the Roman Catholic Church to allow their theories of how the world is constructed to reach the public understanding. In this generation, arguments such as those of Ruse (1998) that nature is subject to empirical law and must be observed, tested and explained in order to be legitimate science have been raised like an impenetrable barrier to keep creationism out of the science classroom. Ruse relied on the assumption that physical laws are immutable: Science is the search for order, unbroken, blind, natural regularities (laws); bodies of science, paradigms, are bodies of laws. Religion, Ruse argued, is not subject to empirical law, but abides instead in the realm of speculation and dogmatic non-falsifiable theories that cannot offer explanation or prediction to further the base of science knowledge.

Anti-realists pushed the definition of the nature of science even further toward empirical law by approaching scientific theory with a kind of agnosticism: There is no objective truth if they can't see it. In other words, indisputable science knowledge is that which can be proven or falsified by observation and testing. Realists responded to this supposition by asserting that science knowledge should not be subject solely to empirical law; knowledge of the unobservable regions of the world can also be constituted science, even though the observable data does not directly support a given scientific theory. This

discussion of the verifiability of scientific theories leads us back to the discussion of what constitutes authentic science. If the line that demarcates science from pseudo-science can be drawn by a consensus of the academic science community based on the realists' interpretation, then the creationists are still excluded but the definition has grown broader than empirical law.

The debate between logical positivists and holists on the preferred way to develop scientific theories offers another example of contemporary attempts to stretch the definition of science past the rigorous boundaries of empirical law. Popper (1998) argued that scientific theories that can be supported by observable data are more likely to yield objective truth about the nature of the world: "Every good scientific theory is a prohibition: it forbids certain things to happen. The more a theory forbids, the better it is" (p.5). Popper recognized a reliance on testability and falsifiability in the line separating science from pseudo-science; this is in response to Marx's scientific theories, which seemed to shift with every nuance in the economic political landscape (Okasha, 2002). Proponents of logical positivism, such as Popper, seemed to try to lift science out of the mire of history and socio-political change, and set it above the mundane on the throne of objective truth. Thus the rational processes of empirical methodology would make science unassailable by doubt: "Science had to achieve the very certainty which had escaped theology" (Lakatos, 1998, p.22). Logical positivists allowed a margin of subjectivity to remain in the "context of discovery," in that inspiration for innovation in science was recognized to come from a variety of irrational sources (Okasha, 2002, p.79).

Thomas Kuhn challenged Popper's theory of falsifiability by placing the development of scientific theories back in a historical context. Kuhn suggested that

scientific knowledge is developed within the historical context of paradigms constructed by the science community. Shifts in paradigms occur when there is a revolution of scientific thought and understanding within the science community, and advancement in science only occurs through a coup d'état of scientific worldview (Kuhn, 1998). Kuhn used political analogies to explain his theory, but this phenomenon can also be observed ecologically. When a natural disturbance such as a tsunami wipes out an ecosystem, native species endemic to the old habitat may not have the resilience to compete against invasive species, and a habitat paradigm shift can occur. Unfortunately, this can mean a habitat that was once replete with a rich diversity of species becomes yet another strip of beach covered with spartina. Kuhn's theory of paradigm shifts through revolutions of scientific thought did not imply a loss of scientific knowledge; on the contrary, he suggested that the crisis of anomalies present in the former paradigm acted as catalysts for a new paradigm of scientific thought to emerge. Consequently, objective truth was subject to the paradigm of scientific knowledge supported and propagated by the science community. Posner and colleagues suggested that conceptual changes in learning occur through paradigm shifts and a process of assimilation and accommodation. In this view, students assimilate new ideas into their current paradigm of understanding which is based, interestingly, not on empirical law, but on an individual's "conceptual ecology," composed of metaphysical beliefs about the world and nature (Posner, Strike, Hewson, & Gertzog, 1982, p.215). The paradigm shift, or accommodation, in this perspective occurs when the central concepts of a student's former worldview yields to the conceptual framework of the new paradigm.

In addition to the debate over what constitutes legitimate scientific knowledge, scholars have debated over whether or not embedding knowledge that is seen to be objective and cognitively rational in a social or cultural context results in a reduction of epistemic value of that knowledge. Digging deeper into the contextual values embedded within the human scientific enterprise, Longino (1990) supported Kuhn's statement that the production of science knowledge is a social process, but took it one step further by asserting that objectivity in science can only be achieved through the subjection of scientific theories to the science community. Within the empirical scientific process, in data collection and analysis, and even in the selection of a hypothesis or research focus, background assumptions particular to the context of the scientist are present. Longino recognized that the production of knowledge can only emerge from an existing social construction of meaning, or worldview: "Science is not a culturally autonomous activity" (1990, p.219). Longino proposed a theory of "contextual empiricism" as the middle ground. Contextual empiricism allowed for the presence of contextual values, background assumptions, within the scientific process. This process included empirical methodology such as testing, retesting, rejecting and reformulating hypotheses, but yielded to the social construction of scientific knowledge. A scientist may approach a field of study recognizing that she brings to it a framework of understanding that is unique to her worldview and background assumptions about reality. At the inception of the process, she may choose the political or economic framework with which to approach the field, and layer that framework intentionally upon the framework of understanding she possesses as a member of the science community. This process of "intentionality of action" emancipated the scientist from the need for science to bear the objective truth

(1990, p.190). Recognition of contextual values and the subsequent submission of scientific theory to the critique and scrutiny of the academic science community freed the individual scientist from the burden of unattainable objectivity.

Donna Haraway (1999) offered a similar middle ground for scientists: the embodied nature of vision. "So, not so perversely, objectivity turns out to be about particular and specific embodiment and definitely not about the false vision promising transcendence of all limits and responsibility. The moral is simple: only partial perspective promises objective vision. All Western cultural narratives about objectivity are allegories of the ideologies governing the relations of what we call mind and body, distance and responsibility" (p.254). In this view, knowledge production is an embodied process, one that we embrace physically through our senses and through being grounded in a specific place, emotionally through our ideologies, politically and socially through the communities that help us shape meaning out of reality. Haraway's concept of "situated knowledge" was not disengaged, disembodied from contextual values, but particular to a community, a place, a perspective (1999, p.258). The community from which a partial perspective emerged proved to be the anchor of scientific knowledge production.

Multicultural Science Education

The question of allowing more partial perspectives of science knowledge into the Western modern classroom is at the center of the multicultural education initiative. Christine Sleeter and Peter McLaren (1995) traced the development of multicultural education and critical pedagogy to human rights movements in the 1960s: the Civil Rights movement in the United States and Paulo Freire's liberation pedagogy movement

in Brazil. Disparities in academic opportunities for advancement were seen to be part of a "culture of silence" in which the dominant culture appropriated agency and cultural identity into "existing regimes of truth" (p.6). These regimes were dictated by economic forces such as capitalism and political forces emerging from a dominant White culture which perpetuated hegemony through institutionalized education. Multicultural education began as a critical response to systemic hegemony on behalf of the people, oppressors and oppressed, who were complicit with it; through the development of critical consciousness, people could resist the culture of silence. As the multicultural education movement gained social purchase over time, the power of the movement to challenge systemic inequities in public schools and effect positive change waned. White teachers and administrators folded the discourses and initiatives into existing curriculum and instructional practices, thus disarming their ability to effect transformative change. "Multicultural education, initially born in liberation struggles, has become a free-floating signifier that is now used in widely differing contexts for conflicting purposes…In other words, difference becomes a marker for novelty while concealing the social, cultural, political, and economic conditions out of which difference becomes valued or demeaned" (p.14). Although ethnically diverse communities such as Native Americans and African Americans continued to push for political change within public schools, the multicultural movement lost much of its critical impetus for change.

However, critical pedagogy retained traction through the critical theory used by feminists in science education to articulate their own epistemology. Feminists who were using situated learning theory to understand how social and cultural forces shaped the learning process developed an epistemology to challenge existing discourses about

science knowledge. In the 1980s feminist theorists Evelyn Fox Keller, Donna Haraway and Sandra Harding challenged the legitimacy of dualism thinking about scientific knowledge that permeated the culture of silence instituted by the Enlightenment. The nature/culture, mind/body, female/male, dominant/other, objective/subjective dichotomies that kept the production and practice of scientific knowledge secured in hegemonic structures were disarmed through situating science learning in the culture and perspective of the learner. Donna Haraway (1988) argued that all knowledge is attained through the partial perspective of the individual; there is no objective reality in science that is separate from this perspective, as stated above. Likewise, Sandra Harding (1991) contrasted the strong objectivity situated within a partial perspective constructed from social and political lenses to historical epistemologies that claimed to emerge from objective places in empirically-based science investigation. Strong objectivity, by contrast, embraced the political and cultural settings that engendered it, and was subject to stricter critique. Thus feminist epistemology in science, recognizing that all knowledge is socially and culturally embedded, demanded a more critical examination of the context in which scientific knowledge is constructed. Science learning identities are shaped, not by learning science content, but by engaging with science in the world: "The challenge for educators is not for enculturating students into existing scientific practices, but rather for educating students so that they may participate in the project of shaping the character of science for the improvement of society" (Brickhouse, 2001, p.293).

Indigenous Knowledge

Other scholars have argued for the inclusion of indigenous knowledge in science classrooms. This academic debate, housed within the current field of multicultural

education or culturally relevant pedagogy, has extended from a debate about the nature of scientific knowledge to attempts to alter the learning terrain by linking indigenous knowledge with science knowledge through border-crossing, bridge-building, and finally the creation of a hybrid or third space (Bhabha, 1994) that allows multiple epistemologies to be positioned as literacies in the classroom. Epistemology is a critical construct for this study: how knowledge is produced and which knowledge has legitimacy within science learning. Increasingly, indigenous communities have claimed the right to establish their own epistemological frameworks rather than rely upon a Western scholar's interpretation of their knowledge. Gregory Cajete (2000) has defined Native science as "a metaphor for a wide range of tribal processes of perceiving, thinking, acting and 'coming to know' that have evolved through human experience with the natural world. Native science is born of a lived and storied participation with the natural landscape" (p. 2). In contrast to Western science, it is relationally-based science that accumulates over generations of interaction between an environmentally-situated people and their historical place. Cajete's interpretation of science gives unique insight into an indigenous people's self-representation within the paradigm of science learning that they have constructed themselves from their own embodied knowledge. It does not conform to the parameters of Western science, but sets a new standard for science learning that privileges indigenous people within their system of knowing and learning. Gegeo and Watson-Gegeo (2001) have argued for an indigenous epistemology that is based on the language and culture of a Native Pacific Islander community; the knowledge produced within this framework is constructed and validated by individuals within a cultural group, based on the knowledge produced in relationship with the land and outside communities, and given

voice by their people. Villagers engaged in critical praxis to process, reflect, and act upon the social, economic, and environmental forces impacting their lives. In a critical ethnography of a Navajo community in San Juan County, Utah, Deyhle (2009) used an emancipatory paradigm to break down the socially-constructed image of the Navajo Indian propagated by the school district in San Juan County, and to interrogate the distribution of power dictated by this mis-representaton. Within the social construct of "manifest manners," White men's assumptions and expectations of the Native identity kept individuals locked down in one stagnant perspective of reality until they could claim their own space within history and within contemporary reality. Deyhle challenged the distorted or "romantic" view of the Navajo as separated "other" through the critical dialectic between "surveillance" and "survivance": Survivance represented more than just cultural survival or assimilation; it was an active resistance to the surveillance of the white man and a rejection of his constructed image of the Indian (preface, p. xviii). Through their stories, women participants gave voice to their choice to maintain a Native presence in the face of the socially-constructed representation of Navajo imposed on them through a discourse of "manifest manners." Storytelling served as a political mechanism by which indigenous people represented their own embodied knowledge, carved out their own pedagogical space and populated it with meaning generated from their own ways of knowing and learning.

Questions have arisen concerning the homogenization of indigenous knowledge that occurs through the process of distilling and cataloging selected portions of knowledge in order to conform it to the Western scientific knowledge paradigm. If the constitution and organization of indigenous knowledge is dictated by the Western

scientific community, or by mediators limited to their own Western partial perspective, the identity of indigenous peoples could be rendered unproblematic and apolitical by means of monolithic categorization as "other." One of the pathogens associated with the institutionalization of indigenous knowledge has been the construction of a monolithic representation of that knowledge. This has displaced the emancipatory energy of recognizing indigenous knowledge as a valid entity and replaced it with instrumental energy compliant with Western hegemony. Nygren (1999, p. 268) has suggested that the construction of monolithic representations for local knowledge creates space for discrimination and marginalization; he proposed an "alternative view of situated knowledges which are simultaneously local and global." Nygren's study of the migrant populations displaced by the contra war in Nicaragua situated their knowledge within the historical narrative of political upheaval and disconnection from their land, which was a poor fit for the paradigm of indigenous knowledge propagated by the Western development discourse. Local knowledge, by the latter definition, emerged from an incubator of time and place and was legitimated by consistent interaction with the environment; in this categorization, migrant or displaced populations were pushed to the margins as alien "other." The migrant peasant communities that hugged the border zone of Rio San Juan in Nicaragua saw themselves politically, historically and socially as loggers or farmers, as Sandinistas or Liberals, as Catholics or Protestants, as women workers, as cattle-owners. The knowledge they used to relate to the forest was a hybrid mix of traditional and imported. One healer traced his knowledge to his uncle, Catholic monks in Chontales, the indigenous herbalists on the Atlantic coast, USAID rural health

workers, training from the Ministry of Health, and his experience as a guide for foreign ethno-pharmacologists and bio-scientists (1999, p. 278).

The question of what constitutes legitimate indigenous knowledge and how that knowledge functions in relation to the distribution of power remains critical to a discussion of the integration of indigenous knowledge into science education. William Cobern and Cathleen Loving (2001) have argued that indigenous knowledge must remain apart from Western scientific knowledge in the classroom if it is to avoid assimilation into the dominant Western interpretation of science. They recognized that Western scientific knowledge has preempted local knowledge in classrooms around the world, and local understandings of science are in danger of being marginalized because they are viewed as embedded within cultural traditions. Even though indigenous knowledge has contributed significantly to the body of scientific knowledge and should be preserved, the domains of that knowledge needed to remain separate to maintain the integrity of each. In that Western science has come to be associated with institutions of legitimacy such as governments and schools, the assimilation of indigenous knowledge without differentiation could be tantamount to dis-embodiment, in the sense of removing it from its cultural context (Snively & Corsiglia, 2000). Van Eijck and Roth (2007) maintained that Traditional Ecological Knowledge (TEK) and Western scientific knowledge were incommensurable because they applied different epistemological frameworks, the one including cultural reality alongside physical reality, and the other restricted solely to physical reality. Moreover, they argued that the concept of a cultural identity upon which cultural knowledge is founded is a misconception at best; indigenous communities continued to shape their identity from the dynamic flow of past and present, multivocality

and multilocality, in the constant process of shaping and re-shaping knowledge as the community experienced life and nature. Such a flow of knowledge was difficult to capture for categorization and legitimization within the Western science epistemological framework.

Those advocating a universalist/realist approach to the question drew a firm line between Western Modern Science (WMS) and Traditional Ecological Knowledge (TEK). Siegel (2002), writing in response to Stanley and Brickhouse (1994), stated that the objectives of WMS are different from those of TEK: WMS, as defined by universalists, seeks knowledge that is genuinely predictive, and deeply explanatory, theories that are testable and reveal the world that exists apart from our construction of it. By contrast, Siegel asserted, traditional knowledge from economically-marginalized countries is more concerned with retaining old knowledge about the earth than pushing forward to new discoveries. While granting the moral imperative of incorporating multiculturalism into the classroom, Siegel nonetheless upheld a dichotomy between the two streams of science knowledge. Cobern and Loving (2001) raised a different point of contention: while incorporating students' cultural knowledge into the classroom could bring a richness of diversity to science learning, the blending of scientific knowledge streams could produce a homogenization of knowledge that would strip TEK of its unique cultural context. They also endorsed the western assumption that TEK has roots in spirituality; that alone could preclude compatibility in the classroom. At this point in the debate, indigenous knowledge could enter the science classroom as a welcome guest but not as a permanent resident.

Advocates for blurring the line and allowing TEK equal standing in the classroom such as Stanley and Brickhouse (1994) and Snively and Corsiglia (2000) endorsed the view that partial perspectives of science knowledge were not exclusive to indigenous scientists and feminists. Even with the failsafe of peer review instituted by the academic science community to protect science knowledge from the individual scientist's contextual bias, the resulting knowledge might be far from objective. Stanley and Brickhouse cited Harding (1991) to support this contention: Western scientific discourse had become a cultural monologue. The scientific community upheld a standard for knowledge that has been dictated for generations by a white western interpretation of what constitutes science knowledge. It is a question of positionality and power. Although Siegal, Cobern and Loving argued persuasively for an integration of TEK into a science classroom dominated by WMS, there was no question of offering an equal platform. Snively and Corsiglia argued that the science practiced in indigenous cultures has as much merit as western science, and possibly more relevance. Indigenous methods of data collection and analysis may not be as academically rigorous as those of western scientists, but their pursuit of science knowledge for the objective of sustaining their communities yields legitimacy, particularly in the emerging field of sustainability science (Carter,). Longino (2002) challenged the assumptions of this apparent dichotomy of knowledge by asserting that all three senses of knowledge (as content, as practices or procedures, and as state) conform both to cognitive rationality and to the social exercise of interaction and enactment. Longino argued for "an epistemology for living science, produced by real, empirical subjects. This is an epistemology that accepts that scientific knowledge cannot be fully understood apart from its deployments in particular material,

intellectual, and social contexts" (p.9). In other words, the association of science knowledge with social or cultural knowledge does not have to weaken the integrity of that knowledge; instead, it brings it to a fuller realization. The empirical process of engaging in scientific exploration and analysis is inextricably linked to the social process of peer review and dissemination of science knowledge, Longino has argued, and therefore assumptions about the immutability of science knowledge should yield to a more partial, plural and provisional view of scientific knowledge.

Van Eijck and Roth (2007) advocated for a community-based praxis framework of understanding for the construction of science knowledge. This framework centered around situated human activity, and the artifacts of knowledge that were created from the activity, which in turn shaped a dynamic culture within a local context. Narratives or texts that were abstracted from this context became dis-embodied knowledge, lost meaning and even relevance. Nygren addressed this issue with regard to marginalized communities: "In these communities of colonization, where contradictory discourses overlapped and discrepant meanings criss-crossed, all knowledges were made up of diverse elements and combined within a world of multiple actors. Any attempt to draw sharp boundaries around what counted and what did not count as 'authentic' local knowledge proved to be fruitless; rather, there was a need to start to grapple with heterogeneous and hybrid knowledges" (1999, p. 277). Therefore, if indigenous knowledge streams emerged from a confluence of local and global encounters and did not exist historically in discrete spaces apart from articulations of western domination, including Western scientific knowledge (Agrawal, 1995; Pottier, 2003), then the question

becomes one of the location of power. What spaces have local people constructed to identify and legitimate knowledge?

While these arguments problematize the efficacy of integrating indigenous knowledge into scientific knowledge, they do not address the political viability of bridging the gap between indigenous people and the academic science community. Students from communities and ethnic groups who have experienced a transitory lifestyle may have a hybrid understanding of place and culture that does not translate easily into Western scientific categories for learning. Their understanding of scientific knowledge may have emerged from a diversity of perspectives not anchored in any specific time or place. Subgroups within cultures of migrant, refugee or immigrant communities may locate their identities in unpredictable spaces, problematizing the work of science educators trying to facilitate border crossings into the Western scientific understanding of physics, for example (Aikenhead, 1997). Aikenhead has argued that the scientific literacy required by all students to function in their socio-economic realities is embedded in socio-cultural contexts that inform practical real-world decision-making.

Allowing Multiple Epistemologies in the Science Classroom

One paradigm of culturally-sustaining science education that has allowed students' cultural literacies to create a more permeable learning environment called for the "de-settling" of expectations and assumptions implicit within the dominant culture of mainstream education in the U.S. (Bang, Warren, Rosebery, & Medin, 2013). The work done by Chèche Konnen scholars to identify the institutional science-culture divide present in school science and the pathology of powerlessness endemic within that divide for emergent bilingual students has opened space for a new meaning-making discourse

that connects the streams of indigenous knowledge and science knowledge. They applied this approach successfully to science education with Haitian and Latina/o students, opening up traditional science instruction, discourses, and practices in the classroom to create space for multiple voices to emerge from multiple cultural perspectives. Community-based understandings of science knowledge rooted in cultural knowledge have proven particularly effective in advancing the science learning of indigenous students for whom streams of ecological and cultural knowledge form a confluent whole. Indigenous scholars have advocated for the inclusion of cultural knowledge in science learning as a way of educating students through embodied knowledge rooted in their understanding of the world around them (e.g. Cajete, 2000). Similarly, Rosebery and colleagues have advocated for an alternative discourse of science learning that "conceptualizes the heterogeneity of human cultural practices as fundamental to learning, not as a problem to be solved, but as foundational in conceptualizing learning and in designing learning environments" (Rosebery, Ogonowski, DiSchino, & Warren, 2010, p. 323). In applying this concept to their work with immigrant students, they concluded that a blending of scientific discourse with cultural discourse produced a deeper level of conceptual understanding in science learning. In other words, a hybrid space for science learning that produced an alternative scientific discourse was not limited to mainstream meaning-making practices; rather, the underlying assumption was that students with diverse cultural discourses could participate in science as a way of knowing without conforming to the dominant culture.

Research emerging from the Chéche Konnen community has connected language learned in the process of authentic scientific inquiry with the co-construction of meaning-

making in science for language minority students (Rosebery, Warren, & Conant, 1992). Building on Gee's (2001) notion of discursive identity, Rosebery and colleagues have argued that in order for marginalized students to embrace the identity of scientists, they have to be able to learn the language of science as they practice the process of authentic science inquiry: pose a problem; design an experiment to explore the problem; collect and analyze data; develop, reject, re-develop hypotheses and finally develop theories that are supported by evidence. Linguistic knowledge subsumed within conceptual development in science learning can lead to scientific literacy more readily than English instruction set within a knowledge vacuum. Rosebery, et al, advocated for an interdisciplinary approach to science learning that mimics the home literacies and learning environment of the students' families. They suggested that scientific literacy could be viewed through the lens of discursive identity: As students step into the role of scientists and adopt the discourse of science, they come to see science as a socially and culturally produced way of knowing.

Later research emerging out of Chèche Konnen expanded this view of students adopting a particular discursive identity to access science learning to a counter-narrative that transformed the landscape of science learning to a heterogeneity of linguistic and cultural identities (Rosebery, Ogonowski, DiSchino, & Warren, 2010). Rather than adapting students' discursive identities to science learning, the learning environment was seen to be shaped by students' discursive identities: "learning is viewed as an activity in which heterogeneous meaning-making practices come into contact – explicitly and implicitly, intentionally and emergently—to generate new understandings, extend navigational possibilities, and adapt meaning-making practices to new forms and

functions" (2010, p. 324). The learning environment, and the discursive practices generated within, were modeled on the students' communities of practice, thus expanding the space for meaning-making in science for students from diverse communities. In their study with English, Haitian, and Hispanic third and fourth graders, researchers designed lesson plans that brought students' experiential knowledge to bear on their co-construction of meaning in science learning. One student originally from Haiti placed a melted ice cube in the window to see how long it took to re-freeze. The learning environment they had constructed invited him to design an investigation to satisfy his curiosity; the other students, although they may not have shared his cultural knowledge, shared his curiosity once it was legitimated within the classroom. Over time, the elementary students began to embrace a more complex understanding of the particulate nature of matter and phase change through this shared meaning-making process. Researchers concluded that, in both curriculum and instruction, broadening the space for science learning to include a platform of cultural heterogeneity enabled elementary students to cross discursive borders as they populated the space with meaning.

In science education literature, scientific understandings and practices have been limited to the borders of nature and culture defined by Western science scholars through what Bang and Marin (2015) have referred to as the nature-culture divide. By challenging common perceptions of the natural world embedded within science studies that perpetuate the view that humans are distinct from nature, researchers working with indigenous communities and science education have expanded the borders of scientific knowledge to include diverse epistemologies and ontologies. Based on extensive long-term research with the Menominee community in Wisconsin, Bang and Medin (2010)

have contended that a confluence of community-based scientific and cultural knowledge is essential to the cultural process of learning for indigenous students. Whereas the Western epistemology of science might strive toward objectification of nature, indigenous epistemologies have historically sustained a more reciprocal understanding of humans in relationship with nature. When applied to a paradigm of learning that recognized the vitality of cultural knowledge, these ways of knowing could enable students previously marginalized in the science classroom discourse to position themselves as agents in the use and production of scientific knowledge. Advocates of this transformative paradigm of learning challenged the idea that scientific knowledge can be presented to students in the classroom as culture-free objective knowledge, or that culture could be added ornamentally to a science learning discourse: "Native science is not simply folk wisdom accumulated over time that may or may not be 'validated' by modern science; instead, Native science embodies values and epistemological orientations for approaching and understanding the natural world that have integrity in the contemporary practice of science" (Bang & Medin, 2010, p. 1015).

Bang and colleagues referred to the process of re-situating science learning within a more permeable epistemological framework as "de-settling expectations" in science education (Bang, Warren, Rosebery, & Medin, 2013). The expectations consist of assumptions, privileges and benefits implicit to belonging to the dominant culture in this country, that enable the institutionalization and propagation of knowledge through the current education system. The act of de-settling creates space for multi-voiced meanings of core phenomena to enter into the science classroom. To support their argument that the boundaries of traditional scientific knowledge should stretch to accommodate new

ways of making meaning, they cited an example from indigenous scientist Michael Blackstock who presented water as a living organism that played a central rather than a peripheral role in most ecosystems. Rather than subjecting scientific knowledge to the traditional anthropocentric ontology, Blackstock de-settled Western assumptions by centering a living system around water, thus restructuring how science learners perceived the relationship between humans and nature. The authors gave an example of a Haitian immigrant student who described water in the hydrologic cycle as having a "place" to which it belonged; rather than objectifying water, the student endowed water with cultural meaning from his own understanding of the processes of nature (2013, p. 310). The student's way of understanding nature, his values and beliefs in relation to nature, was legitimated in the science classroom despite the common Western assumption that water as a natural resource held value as a commodity only.

Science learning becomes deeply contextualized in this paradigm, allowing students and teachers to develop an "ecological mindfulness" that ties them inextricably to the natural systems around them (Chinn 2015). Cory Buxton's (2010) study with middle-school students engaged them in a learning paradigm that transformed their perspectives of their immediate environment and empowered them to become agents for positive change. Framed by critical pedagogy of place, this research embedded science content in the sociocultural landscape of the students and their communities. Set in an urban seaside nature center as a camp experience, the study engaged students from a variety of cultural backgrounds in a reciprocal climate of learning. Students applied their knowledge of the environment to contemporary socio-scientific problems and designed appropriate actions in response. Through this process, students learned to articulate and

challenge ideas about the environment propagated by the dominant culture, and re-populate their learning space with meaning more in keeping with sustainability science and a reciprocal relationship with the earth. Even though these students did not come from Native American communities, they were able to adopt the discourse and cultural identity of environmental experts and shape their community-based knowledge into a counter-narrative to the dominant culture.

Science Knowledge within a Critical Pedagogy of Place

Critical place-based education turns a critical lens onto issues of race, gender, and class that characterize mainstream education in a particular place, whether rural or urban. "Place-consciousness toward diversity and multiculturalism means reconnecting these themes with the rooted experience of people in their total environments, including the ecological. This rooted experience has both a spatial and temporal dimension; place-consciousness, a place, and the traditions that emerged there, whether these have been disrupted or conserved" (Gruenewald & Smith, 2007, p. xxi). The process of engaging with critical issues in a particular place offers the opportunity for an emancipatory approach to education: Not only can the critical environmental issues engendered by a geographical place in tension with development and commodification be addressed but also the political agenda of dominant discourses present in mainstream classrooms. Gruenewald (2003) referred to this process of engagement as "decolonization and reinhabitation" in which individuals become humanized through a heightened awareness of the oppressive mechanisms of the dominant culture and consequent praxis (p. 5).

Freire termed this process *conscientizacao,* or critical consciousness. Although he did not address restoration of healthy relationship with the environment that Gruenewald

advocated through the concept of reinhabitation, Freire's writings on critical pedagogy urged individuals and communities to reflect on the political tensions of their situationality using their education and take responsibility for effecting positive change (Freire, 1970). In this way, critical pedagogy of place disrupts the complicity of communities and individuals in their own socio-political oppression and also in the destabilization and degradation of the physical environment where they live and shape cultural meaning.

Critical pedagogy of place as a theoretical construct stems from place-based education, a construct typically associated with rural education, and critical pedagogy, a construct based on critical theory (Giroux, 1988; Freire, 1970). Place-based education can be traced back to the experiential learning advocated by Dewey and his ideals for democratic education. Dewey's (1926) writings on democracy and education reiterated his centerpiece themes: the importance of communication ("All communication is like art") and maintaining an open mind to all perspectives ("In order to communicate well, we have to step into the other's shoes so that we can imagine how they are hearing us"); the importance of maintaining a connection between the learning environment in school and the knowledge gained outside of school; and the role of the social body in contributing to the child's learning experience ("Children absorb beliefs, emotions and knowledge through the intermediary of the environment. As the individual participates in the social environment, he appropriates its purpose and is saturated with its emotional spirit") (pp.6, 26). Dewey challenged the dualism of mind and body prevalent in mainstream educational discourse. In his view, education could be an opportunity for spiritual and moral development when students' innate search for creativity and purpose

were satisfied; the school could become the child's habitat "where he learned through directed living" and cultivated "an openness to the possibilities of the human spirit" (Dewey, 1900, p. 32). He viewed intellectual development in children as having a causal relationship with activity: As children engaged in inquiry-based activity, they learned from the consequences of their actions. Directed reflection upon the consequences of actions led to recognition of meaning, and a deeper understanding of experiences (1926, p.164). Eventually this process could produce a mental discipline of determining the significance of an act: testing theories to determine their reliability or falseness. Science knowledge emerged as a natural result of this process: "By science is meant that knowledge which is the outcome of methods of observation, reflection and testing which are deliberately adopted to secure a settled subject matter…Both logically and educationally, science is the perfecting of knowing…" (1926, p. 256).

By focusing attention on students' immediate communities and "lived curriculum" (Hodson, 2011), place-based education served as a counter-narrative to the narratives of globalization and neo-liberalism. Rather than focusing students' attention on decontextualized science and economic narratives propagated in textbooks, place-based education turned students' attention to their own cultural heritage and indigenous knowledge, narratives that were traditionally marginalized in dominant educational models. For example, the Foxfire publications developed in 1966 in the Georgia mountains connected high school students with the elders in their own communities. Students gathered stories and interviews from local elders in the rural Southern Appalachian community whose culture had been marginalized by globalization narratives of progress and economic development. Sustainability practices handed down through

oral tradition from family to family were captured by students through this learner-centered, community-based educational model and published in *Foxfire* magazine. Local indigenous knowledge situated students within their own lived curriculum by engaging them as stakeholders in local social, political, economic, and environmental arenas in an exercise of mutuality (Bowers, 2005) rather than decontextualized global arenas.

Contextualizing science learning as an embodied activity set within social, historical, political and cultural spaces also enables the student to become an agent for change (Lim, Tan & Calabrese Barton, 2013). Positioning place as a theoretical framework anchors the science learner in real-world problems with which he or she can engage, prompting experiential inquiry-based learning both in and out of the traditional science classroom. For my project with the Karen students, critical place-based pedagogy provided an essential framework for understanding the importance of place to a people who have been displaced for decades. Lim, et al, (2013) argued that place is a critical part of a student's identity development: it affects how a student views the construction of science knowledge, as well as how that knowledge is carried out within a cultural and social context. Embodied science learning could be seen as an evolving process of discourse and identity-shifting as students come into contact with areas of local and global engagement that had not been previously available. Taking science inquiry out of the classroom into an informal science learning environment such as an afterschool program allowed the student participants in Lim and colleagues' urban study to push against disciplinary boundaries so that they could experience science inquiry in a setting that had more meaning for them. The authors described science schooling as "decontextualized, isolated conceptual delivery" compared to the science inquiry students

designed to explore possible responses to a real life problem set in their own city (2013, p. 199). Whereas conceptual understanding in the science classroom can often be anchored by real-life examples, students have more of an opportunity to construct their own meaning when the science investigation is anchored in a real-life problem with which they must wrestle intellectually and practically.

Conclusion

This chapter reviewed the literature on refugees in education with a particular focus on Karen refugees. Refugee students, including Karen refugee students, have struggled to integrate into mainstream classrooms, including science classrooms, without the aid of cultural interpreters. Traditional instructional strategies for ELL students have not been adequate for helping refugee students integrate into a classroom in which the dominant culture is Western. Literature on science education and Karen refugees was unavailable at this time, so I situated this research within the broader discussion of science education and indigenous students. A review of literature on indigenous knowledge yielded the perspective adopted in this research: Indigenous knowledge and culture cannot be limited to the geographical place where heritage knowledge originates. Indigenous people craft their knowledge and culture from many different sources, modern and ancient, and locate meaning in many different places, local and exotic.

In addition, displaced populations, such as Karen refugees, may locate their cultural knowledge in unpredictable spaces. Although scholars have argued that the cultural identity of indigenous people in the age of globalization encompasses a wide variety of Western and native influences, it is reasonable to assume that the Karen people who have resettled in Comer might feel strongly about shaping their own identity as

Karen-Americans. For people who have been involuntarily displaced, perhaps for decades, the need to root themselves in a physical and cultural place where they can carve out their own hybrid identity is a driving force. This view also aligns with the decolonization/re-inhabitation framework of critical place-based pedagogy in that a counter-narrative to that of the dominant culture is intentionally articulated and legitimated. Research on the integration of indigenous knowledge into the science classroom was inconclusive; many Western teachers were unable to bridge the cultural gap for students from diverse cultures.

Critical pedagogy of place works toward the decolonization of current pedagogical practices in mainstream spaces housing Western cultural perspectives and the subsequent re-inhabitation of fresh learning spaces. Therefore attention must be given to the cultural space within which scientific knowledge is constructed and who populates the space with meaning. Chapter 3 describes the creation of an afterschool program that served as a hybrid space within which Karen students could construct their own cultural knowledge. Cultural knowledge prioritized by Karen parents in phase one of this research was represented in the afterschool program by Karen language lessons and a Karen co-teacher. Within this context, this research tried to build a legitimate platform for multiple ways of knowing from which students from diverse cultures could access science learning. Current equity in education research on indigenous populations and science education has suggested that space for multiple epistemologies within science learning can close the achievement gap between students from the Western dominant culture and students from diverse cultures. The afterschool program was designed to house such a space.

CHAPTER 3

Methodology: Action Research with Karen Parents and Students

For this research, I chose an action research design. Action research is characterized by an emancipatory approach, in which participants act as agents with decision-making power in the production of knowledge (Reason & Bradbury, 2008). Lykes and Mallona (2008) located participatory and action research within an understanding of transformational liberation, which has both a psychological and social dimension affecting structural injustice and the transformation of individual identity in relation to forces of oppression:

> "Liberation, as influenced by Freire's 'states of being', is understood as partial freedom from oppressive social, economic, and/or political conditions, whereas transformation is conceived of as a process of individual and/or collective change made through conscientization and praxis. Transformational liberation represents a process through which a shift in consciousness is attained through recognizing individual *and* collective potential and praxis" (p.109).

Emerging out of social movements for change in the 1970s and 1980s in places like Latin America and fueled by educators and community activists, action research attempted to re-distribute power for self-representation and voice to those people who produced their own local knowledge. Within transformative deeply contextualized spaces, people who had experienced oppression through colonialism, racism, gender oppression, poverty or any combination of these could generate their own narratives of truth and counter-narratives of reality (p.110). While action research has moved in recent years from social movements for liberation to more institutionalized settings, education offers an arena for substantial interrogation and transformation of multiracial, multicultural spaces and

discourses (Lykes & Mallona, 2008). In addition to supporting empowerment of participants through agency, an action research design also allows space for participants to generate their own cultural identities. For indigenous peoples, self-representation creates space for the production of embodied knowledge. From the First Nations peoples in Canada to the Maori in New Zealand, ethnographic discourse has portrayed indigenous people as the mysterious "other" (Said, 1978). Linda Smith (1999) challenged the Western academic community to recognize how the concepts of space, time, place and humanity have been subject to Western interpretation to the exclusion of other perspectives, and to the detriment of the global body of knowledge.

Action research works toward the goal of social transformation. In the tradition of Paulo Freire's liberation pedagogy, education is a community-based political enterprise (Torres, 1992). Therefore, this research was intended to be a vehicle for *conscientizaçã:* a critical step in the education and activation of teachers, community members, students, and their families to work for sustainable change in how science learning and teaching occurs with Karen children (Freire, 1970). Karen parents collaborated with me in phase one of this project to identify the cultural knowledge that they felt was essential to the education of their children in America. The stated objective of the research was to create a science learning space and curriculum that privileged Karen knowledge for Karen elementary students. This objective opened doors to Karen homes, community agencies, and the local elementary school and allowed me to establish a level of reciprocity in learning that would not have been possible otherwise. By working collaboratively with Karen adults to glean knowledge about science and education as well as the keystone characteristics of their culture, I was able to cultivate

respect for their cultural heritage and ways of producing embodied knowledge. Through working collaboratively with the principal and ESOL teachers of the local elementary school in the development of a culturally-responsive pedagogy for an afterschool science program, I was able to cultivate respect for the school's ways of producing knowledge. The end goal was to pull all of these streams of knowledge together into a science curriculum and instructional strategy that honored the cultural heritage and language of the Karen people. Phase two of the study relied upon the continued collaboration of Karen parents and Karen elementary students in the construction of a cross-cultural science learning community.

Role of the Researcher

Subjectivity is critical to action research if the researchers belong to the dominant culture. In working with elementary students and refugees in resettlement, I was careful to situate myself within the narrative that I co-constructed with the participants. Rather than positioning myself as an impartial observer on the periphery of this research, I functioned as a teacher in the afterschool program that served as the setting for this project and as a participant in the narrative portraits I used for data analysis. In this way, I did not isolate myself from my participants' activities or the interpretation of the activities. Rooted in a history of the intellectual colonization of vulnerable populations (Smith, 1999), the position of the researcher carries significant weight in educational ethnography. Lykes (1997), in her work with Guatemalan children traumatized by war, situated herself as "other" within her research. She pictured herself as "standing under" her Mayan research participants in a reversal of power that attempted to liberate the population with whom she worked from fear of white people in power (1997, p. 726).

Traditional social science research methods such as surveys or interviews could re-objectify a population that had already been objectified by violence and war. Relationship-based storytelling created a space of mutual subjectivity, where the power of the white "other" was reduced enough to allow members of the vulnerable population to find their voice (1997, p.729). Within the framework of action research, students can find a voice to articulate the ways of knowing that are meaningful to them.

The methodology in this project was designed to allow space for reflexivity throughout the project. It was critical to understand the lenses through which I viewed reality, so that these could be identified in the data analysis, and treated separately from the perspectives of the participants. Rather than battling my White middle-class assumptions, I tried to see the Karen community as they see themselves: not as a community of people marginalized by poverty and economic depression, language and education barriers, living on the edge of North American society, but as a community rich in resources, self-initiative, family and friends, and hope for the future.

The language barrier proved to be substantial in the research project. How could I know that I had understood the meaning behind the halting, adopted English words that the Karen people used to express themselves, particularly in cases when a translator provided an additional lens for meaning to travel through? Richardson and St. Pierre (2005) link the power of language to the process of identity formation: "Different languages and different discourses within a given language divide up the world and give it meaning in ways that are not reducible to one another. Language is how social organization and power are defined and contested and the place where one's sense of self – one's subjectivity – is constructed" (p.961). Without a common language with which

to co-construct meaning, how could any of the data produced through this project be considered reliable? Even with visual and narrative data to support data gathered in more traditional ways, the gap of understanding seemed to yawn wide between my limited understanding and that of the Karen participants.

In addition, the Karen adults who participated in the study were painfully reticent. I found myself directing aspects of the study that I had intended to be collaborative. In Kazubowski-Houston's (2010) study with Roma women, she had originally intended to write and orchestrate a play with the Roma women about their lives. In her mind, she saw their lives as embattled with hardships and discrimination. After a summer of building relationship with the Roma women, Kazubowski-Houston found herself discarding all of her original ideas for research. The women were not interested in producing or appearing in a play that displayed their hardships; they wanted to produce a dramatic presentation of their lives that gave them the appearance of success and prosperity. They wanted to appear strong in front of the audience. In the end, Kazubowski-Houston published a reflexive account of her failed attempts at performance-based collaborative ethnography instead of the critical emancipatory work that she had hoped to produce. In the same way, I had imagined that the Photovoice methodology would allow Karen participants the space to express themselves without reservation. The visual narratives that resulted, I thought, would provide insight into the political and cultural complexity of their lives, both the painful aspects of emerging from decades of displacement, and the difficulties of becoming citizens in a new land. However, the Karen parents chose to take photos of what I would call "typical" subjects: the family standing together in front of their house; shots of extended family members in

their houses; the parents posed in front of their plot at the community garden site; the new Karen specialty food store that one family had opened in town. All points of pride. I found myself suggesting places and points of interest that they could consider for their photographs. It became less of a self-directed activity that could result in *conscientização* through meaningful dialogue, and more of a project directed by my assumptions of what they would consider meaningful.

Role of the Translators

Although all of the interviews with students were conducted in English, most of the interviews with Karen adults required an interpreter. For phase one of the research, this Karen couple not only hosted all but one of the interview sessions and the focus group in their home, but they also served as translators and interpreters. The qualitative research literature addresses the difficulty of establishing reliability if a translator other than the researcher has to be used for cross-language interviews. In some cases, the translator conducted interviews independently and then gave summaries in English to the researcher (Williamson, Choi, Charchuk, Rempel, Pitre, Breitkreuz & Kushner, 2011). Researchers determined that this approach did not yield full disclosure, even though the translator was trained in research techniques. Nuances in meaning could be lost in translation even when words are translated verbatim. At root is the concern that translation would sacrifice integrity for expediency; in other words, performed carelessly, the shifting of words from one language to another can involve the shifting of power as well. For a people who have struggled with social invisibility, language can be a source of social legitimacy. Temple and Young (2004) suggested that when the translator is incorporated into the study as a participant, particularly as someone who participates in

the construction of meaning through language, then their perspective can be integrated into the research analysis along with that of the researcher and the participants. Since my understanding of the language spoken at home by Karen adults was minimal, I relied upon Mary and Joseph to translate and convey the meaning of my questions to Karen adults, and convey the meaning of their responses to me. In this respect, it was important to spend extended time with my primary participants, collaborating beforehand on the research design and purpose.

Research Questions

A. Phase one of this research project focused on the cultural and scientific knowledge of Karen parents. For this portion of the research, the following questions were explored:

    1. What key aspects of their culture do Karen parents identify as critical to the healthy development of their children's cultural identity as Karen Americans?

    2. Of those, which contains the most potential to contribute to a cross-cultural science learning community for Karen students?

B. Based on the keystone cultural characteristics identified in phase one of this research and building on the insight of similar research projects in the literature on culturally and linguistically marginalized students and education, phase two of this collaborative research project with Karen adults and students explored how explicit teaching on cultural knowledge impacted science learning and cultural resilience in elementary level Karen students. The following research questions guided phase two:

    1) How does the construction of a cross-cultural learning community that privileges Karen cultural knowledge affect the science learning of Karen student participants?

2) How does the presence of Karen cultural knowledge represented by a Karen co-teacher and the Karen language affect how students position themselves within the learning community?

Research Questions	Methods Applied
A1 & 2	Photovoice: visual narratives and focus group discussion; ethnographic semi-structured interviews; participant observation at community events
B1	Participant observation at school and community events; semi-structured interviews of students and Karen co-teacher; Photovoice: visual narratives and focus group discussion; videotapes of the afterschool sessions
B2	Artifacts from afterschool program; teacher's journal; alternative assessments from afterschool program; videotapes from afterschool program; ethnographic semi-structured interviews with students

Data Collection and Analysis

Phase one of the research took place in the summer of 2013 with seven Karen adults in a small rural community in the southeast U.S. (see graphic illustration below). The purpose was twofold: 1) Test how effective Photovoice was with Karen adults in preparation for using it with Karen students; and 2) Build a baseline of Karen cultural knowledge for the upcoming research with Karen students, and establish a relationship based on trust in the process. The overall purpose of the research with adults was clearly stated during the interviews and photo collection of phase one: to discover what aspects of the Karen culture would be important to include in a cross-cultural afterschool program at the local elementary school. In the summer of 2012, I initiated Sgaw-Karen language lessons with a member of the Karen community, Mary, who had been

recommended to me by a friend. I had met Mary and other Karen families at the community garden at Jubilee Partners, a residential transitional community with whom refugee families could live and learn about American culture for their first three months in the United States. For nine months, I drove out to Mary's house one afternoon a week for two hours of conversation and instruction. Mary and her husband Joseph shared my vision for the science education of Karen children, and became my primary participants and interpreters for this research. Other adult participants were recruited through Mary, who made recommendations about which parents to invite to participate in the project. In addition, I attended several Karen community events as the guest of one Karen family with whom I had shared many meals, visited the community garden and the Karen church.

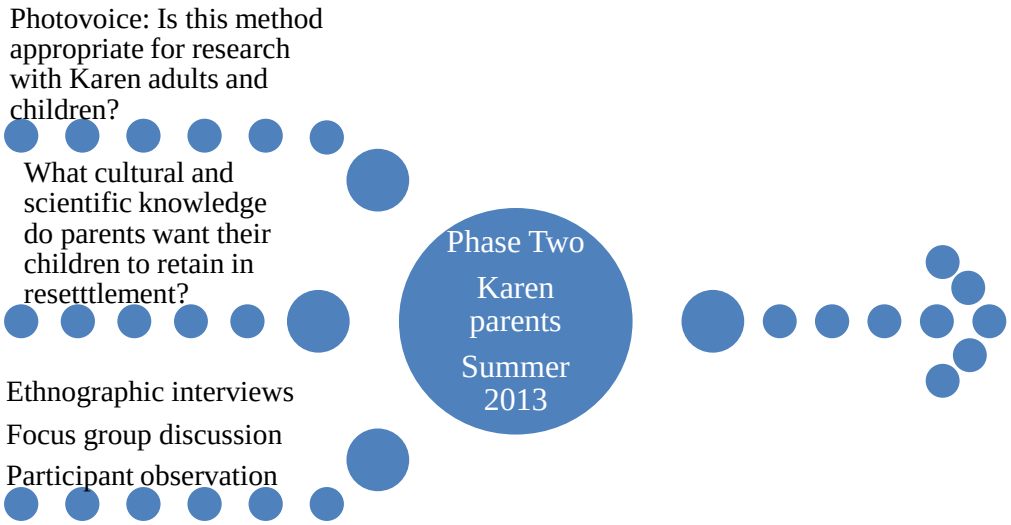


Figure 1Phase One Methods Graph

Phase two of this study took place in September 2014 through January 2015, and ended prematurely due to the loss of the site. The vehicle for this part of the study was an afterschool program that Karen parents and I designed to incorporate as much of the

cultural knowledge they articulated as possible, including the language (see graphic illustration below). In the following sections, I delineate the methods used for this two-part study, touching on why I felt they were appropriate for this research with Karen refugee parents and students, and how they were applied. Many of the same methods were used in both phases; however, a description of the methods is given in greater detail the first time it was applied. A rich description of the afterschool program, including the curriculum we designed, and the instructional strategy we chose, and the rationale for those, dominates the section on phase two.

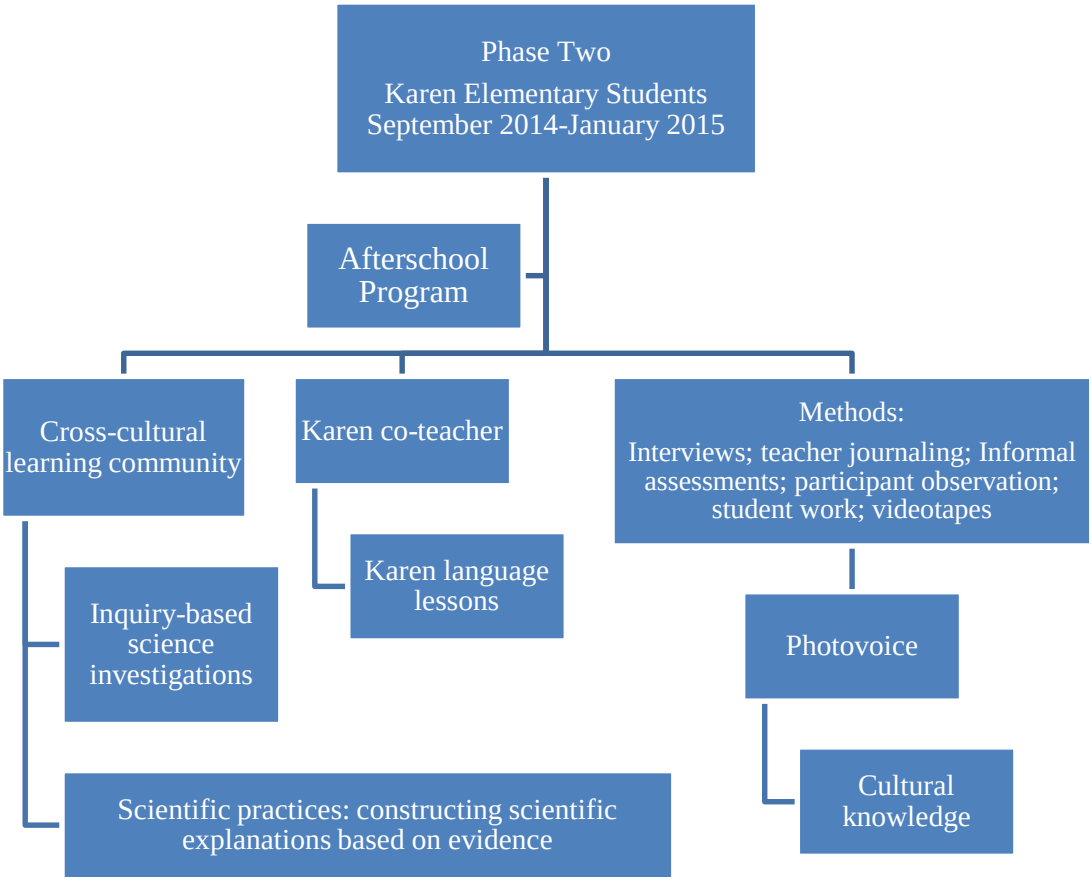


Figure 2Phase Two Methods Graph

Phase One: Research with Karen Parents

Data collection for this project used ethnographic interviews (Spradley, 1979) (see Appendix B for the interview protocol) and participant observation (Spradley, 1980) at Karen community events to triangulate with the data collected through Photovoice. Since the stated purpose of the study was first, to explore what cultural knowledge Karen parents wanted their children to retain, and second, to build that cultural knowledge into a science learning program to discern what impact if any this had on how Karen students shaped their science learning identities, it was essential to develop a rich understanding of the Karen culture throughout the process, and to allow that understanding to change and adapt through meaningful contact with individual and community narratives.

Phase One: Interviews

Spradley defined *culture* as "the acquired knowledge that people use to interpret experience and generate social behavior" (1979, p. 5). Within the context of ethnographic research, interviews contribute to the researcher's search for how participants conceptualize their culture and their relationship to that culture, both in parts and as a whole (p. 93). Therefore, questions take a variety of forms: descriptive, structural, and contrast. Descriptive questions set the tone for the interview, allowing the participant to reveal as much or as little information as they desire, based on the relationship the researcher has cultivated with the participant (p. 60). In my interviews with Karen parents, descriptive questions such as the following set the tone for the interview:

> What is your name?
> How long have you been here in the United States?
> Where were you before you came to the United States?
> Where are you originally from?

What do you remember about your home?
What work did you do there? What work do you do here?
Tell me about your family. Where does your family live?

Structural questions followed descriptive questions with the intention of probing for a deeper understanding of Karen cultural knowledge, the knowledge that parents retained from Thailand and Burma, and the knowledge they chose not to retain. These questions sought to establish *domains* of knowledge (p. 60):

Can you tell me three things that you like about living in Georgia?
Can you tell me three things that are very different from your life before in _____?
What parts of your life do you consider to be uniquely Karen?
What parts of your life now do you consider to be uniquely American?
What parts of your life are both Karen and American?

Interviews with parents took place primarily at Mary and Joseph's house; I was welcomed as a guest into their home. Food was usually served by Mary, fresh fruit or a snack in a Thai wrapper from the local Karen store. I made arrangements for each interview with Mary, setting the time on Saturdays when couples might be free, and arriving on time. On one occasion the parents and children were dressed with care and sat formally on the couch during the interview. On another occasion, the couple were late arriving and Joseph had to go find them at the community garden and bring them back to the house. Spradley (1979) has defined the ethnographic interview to be similar to a friendly conversation, in which the person being interviewed teaches the researcher about her culture. Even though I asked the same carefully structured interview questions to each parent or couple of parents, the parents would often open the topic up for collective discussion, and extended family members, and Mary and Joseph as translators, would contribute to the general thinking about the question. What began as a single semi-

structured question to one or two specific adults resulted in an informal group discussion of life in Burma or Thailand or in the refugee camps. Often our informal conversation about the question would turn in a direction that I felt was relevant to the research project. Mary and Joseph had assumed ownership of my research project; they refined and directed parents' responses as they deemed necessary. Since most of the informal conversation took place in the Karen language, I relied on Mary and Joseph to relay the response they felt was relevant to the question. Even though I audio-taped all of the interviews, I could only transcribe the English portions of the interview. Because Mary had health constraints, and Joseph worked a full-time job, I did not ask them to transcribe the portions of the interview which were in the Karen language.

Phase One: Photovoice

For this research with a vulnerable population of first generation refugee families, most of whom did not speak English, a methodology that allowed participants to represent themselves in a visual narrative was critical. Photovoice allowed participants to define the spiritual and emotional parameters of their community and individual narratives with visual representation. A methodology that has been used extensively with vulnerable populations, Photovoice originated in the 1990s with the public health research of Dr. Caroline Wang. Wang and Burris (1997) drew upon feminist theory and the critical pedagogy of Paulo Freire to construct this methodology, with the explicit purpose of empowering local communities to not only represent themselves to the public but also to work for long-term systemic change by presenting their work to policy makers. Within this study, Photovoice provided a platform from which emergent bilingual students and parents could articulate embodied knowledge independent of the

researcher's lenses. I used Photovoice as a method of visual ethnography to capture the relationship of Karen parents and students to their cultural landscape as it had been constructed by the Karen community in this rural town, and to any community of practice that informed how they produced scientific or cultural knowledge. Within the larger framework of participatory action research, visual ethnography allowed refugee participants to define their own communities of practice and the embodied learning that takes place within those communities. It created space within which culturally diverse people could speak in their own voice from their own legitimate experiences and literacies.

For refugee students and parents, visual ethnography provided a means of creating a first-person narrative apart from the dominant discourse of the written word. Pink (2007) suggested that the dominant discourse in social sciences is the written word; therefore, images have the power to generate new types of knowledge. In visual ethnography, there can be no objective truth, only the meaning given to images by the ethnographer. The only legitimate way to interpret visual data is reflexively, acknowledging the personal lens through which images are filtered as well as the lens of the culture in which the images are embedded. Interpretation of visual artifacts is completely subjective, and based on the actor's own experience of socially-constructed reality. This approach provides a unique venue for an actor to represent her own cultural identity, however hybridized by extended contact with the culture in the United States. For the researcher, visual ethnography provides a way for a member of the dominant culture to step to the periphery of a community of practice and adopt a position of relative voicelessness and powerlessness. Although the researcher's own interpretation of events

inevitably contributes to the construction of meaning that takes place within the visual ethnographic activities, she is able to take a reflexive stance that clearly identifies her own perspectives within her own communities of practice. From this embodied position, the researcher can consume less space in the process of co-constructing knowledge with vulnerable populations.

Photos for the Photovoice exercise were collected as part of the interview process in phase one with Karen parents. Once the interview was completed, each couple used an iPad to take photos of any place, person or thing that held meaning for them. I drove the participants to multiple local sites so that they could take photos of extended family or geographical places, such as their plot at the community garden. This process usually took 1-2 hours and served as an opportunity to step outside the more formal structure of the interview process. Participants tended to relax more during the photographic sessions, and seemed to welcome the opportunity to share what was meaningful to them. We took several trips to the houses of extended family members, and children figured prominently in these photographs. Immediately after these sessions, I recorded field notes in a journal. These notes were later incorporated into narrative portraits of the participants.

A focus group discussion followed all of the interviews with parents. Mary and Joseph hosted the gathering at their house and provided Thai food. The focus group protocol (Appendix C) was designed according to Photovoice specifications. During the focus group discussion, couples were asked to identify the photos that most closely represented their cultural identity here in the U.S. and held meaning for them. This discussion was videotaped and transcribed for analysis. After a shared meal, we sat on a

woven rug and each couple spread their photos out in front of them. I asked each couple to select five photographs to discuss with the group. During the following discussion, couples identified the photos that most closely represented their cultural identity here in the U.S. and held meaning for them. Since most of this discussion was in Karen, Mary and Joseph translated for me. Each participant was given an opportunity to speak; a third party videotaped the discussion and I took notes. At the end of the meeting, I thanked each participant and promised to give them a copy of the narrative portraits that Mary and I would produce as part of the data analysis.

Phase One: Participant Observation

Participant observation for phase one took place primarily at the community garden on Saturdays where I visited frequently with Mary and Joseph in the summer, and at community celebrations. This Karen community had many community celebrations throughout the year, all of which had a worship service as the centerpiece. For example, I attended birthday celebrations for children that were primarily composed of a worship service led by the Karen pastor and a community meal hosted by the child's family. In addition, the Karen Christmas and New Year's celebrations revolved around a community worship service. In phase one, field notes from the interviews, the excursions to gather visual data, and the shared meals that followed provided valuable insight into the Karen culture. Participation observation during two community-wide celebrations of children's birthdays and their parents' achievement of citizenship provided a source of triangulation of data by supporting or refuting statements made by the participants during interviews.

Phase One: Data Analysis

Data from the interview transcripts, participant observation field notes, and focus group discussion were analyzed using thematic narrative analysis (Riessman 2008) to identify distinct areas of cultural knowledge valued by this Karen community. My objective in using narrative analysis was to capture creative constructions of the past interwoven into the reality of the present. It was important to allow space for participants to interpret past events in their own voices, shaping history to fit their image of who they are and who they imagine they will be in a blended Karen American culture. From these narratives, I could see how individuals participated in the production of a social memory, which anchored them in a climate of belonging rather than invisibility (Eastmond 2007). For example, Eastmond described how a headman under the rule of the Dalai Lama's government in exile created a myth to give cosmic significance and a historical place to the experience of suffering that people were enduring. She determined that narratives and myths in Hmong refugee camps provided "a creative revitalization of Hmong culture" that in turn emphasized unity in the face of disorder and violence (Eastmond 2007, p.256).

In addition, I used Clandinin and Connelly's (2000) three-dimensional analytic frame as a tool to identify physical and emotional spaces that participants populated with meaning. Within this Dewey-based construct, three complementary narrative inquiry spaces focus attention on personal meaning and social significance: situation (place); interaction (social and personal); and continuity of events (this space contains historical as well as emotional currency, as participants look inward, outward, backward and forward through time).

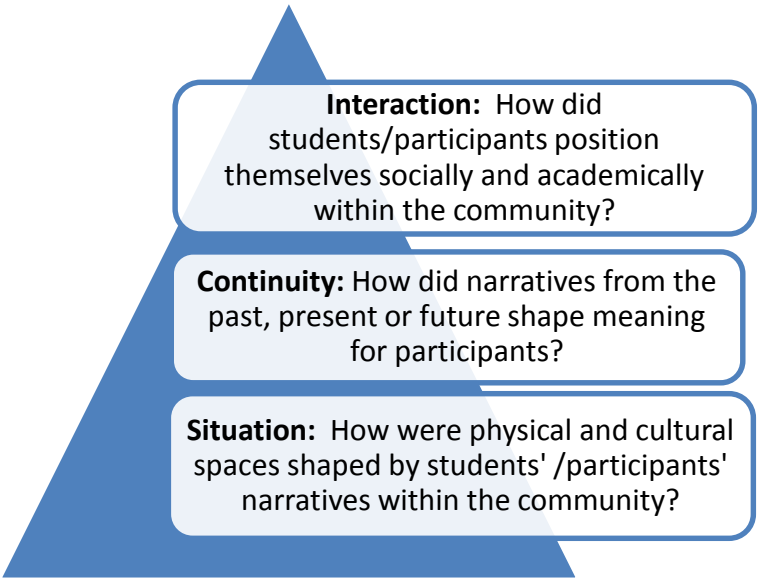


Figure 3 Clandinin and Connelly's 3-dimentional analytic frame applied to this project

I used open coding to identify these spaces, looking for connections or disconnections of fragments of meaning to the whole in the written and visual narratives. For example, five of the seven adult participants identified the community garden as a physical place that connected them to memories/narratives from their past (stories of home gardens or animals they remembered from their childhood in Burma), yet they also populated that space with meaning for the present (the space functioned as a community center for the families in that area, a place where they could gather safely and speak their language), and for the future (they spoke of establishing a self-sustaining lifestyle through the garden). Clandinin and Connelly referred to this concept as "memory boxes" in which past, present and future narrative threads are woven together (2004, p. 66). The integration of past with present and future was essential for refugee parents and students so that any emotional trauma they may have experienced was not silenced or devalued by a host culture that could not relate to that part of their cultural identity (Mosselson 2009). As first generation immigrants, parents in this Karen community played a pivotal role in

constructing a social narrative that gave meaning to and legitimated their past, present and future cultural identity; however that changes and adapts in the future, it served to build resilience for the community in this moment.

Once the spaces emerged from the narratives, I looked for common themes, acknowledging at this point that any identifiable themes would be subject to my own interpretation of the data based on my own experiences and knowledge. As the primary researcher, I was aware of my own cultural and linguistic barriers to understanding and how these would impact my interpretation of the narratives. Working with people who had emerged from decades of violence and discrimination necessitated that their stories, essentially their lifelines to the past, present and future, be represented with as much integrity as possible. From this analysis, domains of knowledge emerged fairly easily, since all of the participants were eager to share their stories and to participate in the Photovoice exercise.

Phase One: Narrative Portraits

The visual narratives produced through Photovoice were woven into narrative portraits (Lawrence-Lightfoot & Hoffmann-Davis, 1997) to produce a "quilt" of multi-layer meaning emerging from multiple voices (Ellingson, 2009). I constructed narrative portraits for three Karen married couples, including the couple who translated for me. I also submitted the portraits for accuracy to Mary and Joseph as a way to member check. The language and cultural barriers were profound in this study. In order for the Karen participants and their knowledge to be adequately represented, a venue that brought together their written and visual narratives into one coherent, fluid story was paramount. Sara Lawrence-Lightfoot and Jessica Hoffman Davis in *The Art and Science of*

Portraiture (1997) defined the researcher's role as peripheral but present. She is the witness, viewing reality through her unique angle of vision, but staying clear of the center frame. From that vantage point, she can describe not only the action and principal actors but also how the actors shape, disturb and transform their environment and interact with each other (1997, p. 59). The researcher's participation in the shaping of meaning is clarified through explicit documentation of dialogue and activities shared with the participants. This reduces the opportunity for objectification to occur; the researcher becomes vulnerable with the participants. With traditional methodologies, objectification can occur by projecting an unnatural, unwarranted spotlight on a person, thus rendering them a source of wonder, or by ignoring them, thus rendering them invisible. In either case, the boundaries are established and the other is outside. Narrative portraits can be a way to humanize someone who appears to be different, find points of connection and commonality, and weave them into the fabric of the larger community.

Narrative portraits (see Appendix A for an example) were constructed immediately after an interview session and a 2-hour excursion to collect photos on the same day. Sources included quotes from the interview, informal conversation during the excursion, and bits of conversation from other occasions when the participant interacted with me or with other Karen community members. My relationship with the participant colors the portrait; I am blatantly present in the narrative. The goal was to re-present the participant as an embodied actor in the construction of her own narrative portrait. To that end, blocking out names and personal information to protect the identity of the participant proved futile. This was a limitation of this form of analysis; although creative in its representation of the participant, it is not effective in protecting the participant's identity.

Phase One: Crystallization

In this two-phase project, crystallization was the approach used for final analysis, and narrative portraits were the centerpiece of that process. Linking Photovoice with narrative portraits through crystallization provided a way to create multi-genre representational space for people who have learned to cultivate silence and invisibility as a means of survival. Ellingson has described crystallization in qualitative research as: "multiple forms of analysis and multiple genres of representation" woven together to build "a rich and openly partial account of a phenomenon that problematizes its own construction, highlights researchers' vulnerabilities and positionality, makes claims about socially constructed meanings, and reveals the indeterminacy of knowledge claims even as it makes them" (2009, p. 4). One of the limitations of Photovoice is the researcher's dependence upon the participants' willingness to speak about their past, present and future. The photos only have meaning if the participants weave them into a narrative. The Karen families who participated in the first Photovoice project shaped their responses around the researcher's lead; in other words, they answered the questions literally and without elaboration even when prompted to expand. Even though I had spent some time in the community, and carried the endorsement of Mary and Joseph, leaders of that community, my membership in the dominant culture could not be avoided. Although Photovoice is designed to bridge many gaps between the researcher and the participants, the researcher does not escape the role of privileged "other." In addition, whenever an authentic experience is translated into a narrative, whether by the participant or by the researcher, bias on the part of the researcher and the context of the storytelling itself creates filters through which the narrative is sifted: "As a result, an experience is never

directly represented but edited at different stages of the process from life to text" (Eastmond, 2007, p. 249). Narrative portraits potentially bridge the gap created by a language and cultural barrier, and help to overcome the residue of a violent oppressive past. Participants are not presented through the researcher's eyes as objects of curiosity, but appear wholly human through a relationship with the researcher. The researcher is also compelled into a position of vulnerability with the participants. The final portrait reveals a subjective multi-layered reality that would not have been possible with Photovoice alone.

Phase Two: Research with Karen Students

The afterschool program which served as a vehicle for this project ran from 3-4:30 on Thursdays beginning September 4, 2014, extending mid-way through the following January. The elementary school allowed us to use the newly-constructed classroom of the science and social studies teacher for the 4th and 5th grades. Under the advisement of the district office, school officials had decided not to collaborate with us in the afterschool program. This altered the original design of the research project significantly: Whereas the original design called for an Advisory Panel composed of parents, teachers, school administrators, and the researcher to oversee the project, this decision nullified that option, in effect isolating us from the larger school community. We were allowed to use the space from 3 to 4:30, and we could recruit students from the existing fee-based afterschool program. Those students who were recruited out of the afterschool program returned to that program at 4:30 where they waited for their parents to pick them up from the school. We drafted a flyer to recruit students from this program. However, none of the Karen students were registered for the existing

afterschool program, so we were responsible for driving all of those students home once the program ended on Thursdays. We also assumed the responsibility of providing a snack for the Karen students; the regular afterschool students received a snack in their program. When we began the program at the beginning of September, we had twelve students, five non-Karen 4th and 5th graders recruited from the afterschool program run by the school, and seven 4th and 5th grade Karen students. The Karen students were recruited through home visits by the researcher and a Karen parent, Mary, who acted as translator during recruitment and as co-teacher during the afterschool program. Over the space of two Saturdays, we visited the Karen students' families in their homes, talked about the afterschool program, and reviewed the consent forms carefully. Even though these had been translated into Sgaw-Karen, we did not assume that the parents could read them. We talked through each aspect of the project and explained each data collection method in detail. All of the parents agreed to have their children participate.

Two weeks into the program, a scheduling conflict arose: the much-anticipated Fit Club (physical exercise outside), open only to 4th and 5th graders, was going to be offered on Thursday afternoons as well. In preparation for the afterschool program, the Karen co-teacher and I had visited all of the Karen families, obtaining permission for their children to attend and to participate in the research project. Also, in compliance with the expressed concern of the school officials, we made sure that a parent would be home to receive the younger children off the bus Thursday afternoons since the older siblings would be with us. After all of these arrangements, we did not feel we could change the day of our program in order to avoid a conflict with the Fit Club. For example, on the first day of our program, one of the Karen parents was not home, and the

bus had to bring the younger children of that family back to the school, where they were added to our program. This problem was easily addressed but illustrates the importance of maintaining consistency with the Karen parents. As a result of the conflict in programs, our numbers were reduced to ten: three non-Karen students, one of whom participated in Fit Club and then joined us afterward; and seven Karen students, one of whom slipped away to join Fit Club even though he was not registered for that program. He also came to our program once Fit Club concluded, usually around 4pm. One of the Karen students moved to Atlanta with his family shortly after the school year began. The final student count was nine: six Karen students, and three non-Karen students, two of whom did not participate before 4pm.

Within this physical space, mainstream discourses had already been established that did not include Karen cultural knowledge. In order to create a more equitable learning space for Karen students, who may have encountered narratives at home that cultivated a need for invisibility in public settings in which they were a minority, it was important to re-organize the physical space so that it privileged the Karen culture. Toward that goal, we accessed Karen community funds of knowledge and chose to use the central floor space as our primary learning space rather than the desks that surrounded that space. In preparation for the afterschool program, we laid a large woven mat on the floor that duplicated the mats many Karen families used in their living space at home. For the language and science lessons, we all sat on the mat on the floor, after removing our shoes. Again, it is culturally appropriate to remove shoes when entering a Karen house and to have meals and visit with one another on a mat on the floor. We also served snacks derived from seaweed, pineapple, pumpkin and coconut purchased from the Karen

grocery store located near the school. For the first meeting, we brought in sweet rice rolled up in banana leaves, a snack that I had been served many times in Karen homes. Although the non-Karen students were hesitant to try these snacks at first, by the end of the program, they were enthusiastic about the Thai-Karen snacks. In addition, we physically transported all of our materials into the classroom from the car in the quarter hour before the program began every Thursday. Parents lined up in their cars to pick up their children, teachers and the school administrator who were lined up outside and in the hallways to facilitate this process, and students being picked up by their parents all observed this ritual. The Karen teacher and I usually made several trips back and forth to the car, depending on how much material we needed for the day's activities. This underscored the fact that we did not belong at the school; rather, we were temporary lodgers expected to remove all trace of our program at the end of Thursday afternoons.

Early in the program we observed that students were very restless when they first arrived in the classroom at the end of the school day. Rather than institute activities for this period, we allowed fifteen minutes for snack and games. This game period became critical to building cross-cultural social relationships within the community of learning; social interaction in large part dictated cultural legitimacy within the group. I brought in games such as Apples to Apples and K'nex models that could build literacy; later when the students became interested in the culture of Africa, I brought in Mancala. Two of the Karen boys demonstrated expert knowledge in this game that drew the other children in to watch. This became an opportunity for the boys to teach the other Karen and non-Karen children how to play the game, creating a platform for them to use funds of knowledge to build social credibility and leadership within the group. On another

occasion, Karen and non-Karen students arm-wrestled on the floor during the game period. Social interaction between Karen and non-Karen students became more common as the program progressed but we began from a position of separate social groupings depending upon ethnicity and gender. One non-Karen student in several of the videos has removed himself from all of the activities by sitting on the edge of the student group during the game period and the language lesson, even going so far as to pull his hood up over this head to emphasize his isolation. Once the other male non-Karen student joined our group after Fit Club, he became animated and participated much more readily in individual and group activities. Students could also choose to draw or use the laptop or ipad during this period; social structure was not imposed during this period at all.

The decision to distribute power in order to create a cross-cultural learning community that was not dependent on the teachers created cultural tension in terms of behavior expectations of Karen parents. Although we were not successful in recruiting Karen parents to help with the afterschool program on a regular basis or to serve as guest speakers who could share family or community funds of knowledge, my Karen co-teacher expressed concern about the students' behavior after the second session. In informal conversation after driving the children home, she said that Karen parents in general do not tolerate behavior that seems disrespectful to the teacher or to elders in general. She implied that the behavior of Karen children is strictly monitored and modified by parents. This created tension in the basic structure of the project, in that we were not adhering to Karen cultural norms. We agreed that the program needed to be modified in order to minimize opportunities for uncontrolled behavior without limiting opportunities for engagement and participation. Beginning the following week, I brought

in games for the students to play as a group during snack time. This seemed to create a more respectful learning environment, particularly when the teachers participated in the games. After several sessions of the afterschool program, the Karen co-teacher compared the interactive instructional style we were using in the program to the didactic instruction she had received as a child in Burma and Thailand. She said that in those learning environments, students repeated questions and answers after the teacher; they did not engage in critical thinking or problem-solving. By the end of the program, when she and I were conducting final interviews with the students, she said she was impressed by the amount of knowledge the students had retained in our program through the community of learning approach.

The Sgaw-Karen language lesson taught by Mary served as the centerpiece of Karen cultural knowledge. It was offered every Thursday from 3:15 to 3:30 by the Karen co-teacher. For this lesson, Mary sat on the floor in front of the whiteboard and wrote Karen letters and words on the board, asking the children to repeat them after her. Interestingly, she developed a hybrid instructional strategy that combined the didactic style of her childhood with the interactive instructional style I was using in the science lessons. Although the interactive style, as discussed above, allowed for less student control, she invited students to come to the board and write the letters and words themselves, often with no or little prompting from her. In this way, Karen students who had learned some of the written language from their parents could demonstrate their expert knowledge and build academic capital in the learning community. Although all of the Karen students spoke only Karen or Karenni at home with their families, not all of the Karen students had learned to write or read the language.

Whenever possible, we tried to use the funds of knowledge (González, et al, 2005) of the students participating in the program in order to bring them from the periphery of the learning community to the center. For example, one 4th grade student had already constructed a model of the phases of the moon in a school project; we asked him to bring that in for the other students to see so that they could begin to understand the importance of modeling to conceptual understanding in science. Later, when students constructed their own models of the phases of the moon, although these were distinctly different from the exemplar they had viewed, they understood the importance of modeling and approached the project with enthusiasm. In another example, one of the Karen students used his time at the beginning of the first few sessions to shape paper airplanes and fly them around the room. As a learning group, we studied the physics of force and motion a week later and built on his knowledge by developing our own paper airplanes and flying them down the hallway, competing to see which airplane could fly the greatest distance with the greatest speed. We shaped this into an experiment by attaching a paper clip to the airplanes at a key position and recording how that affected its flight. Two of the students who did not wish to participate in the contest measured the distances and speed of each airplane, recording the data on the whiteboard so that we could construct it into a scientific explanation later. In this respect, I developed a model of lesson-planning based on the ecological cycle of planning, performance and assessment that could be adapted to students' existing knowledge. I prepared science lessons the week before the afterschool program, modifying and adapting them to fit the knowledge that the students had constructed in the previous session. Reflection and

assessment were on-going in terms of integrating cultural learning into the science learning curriculum.

The importance of "place" and belonging to a local community was to be the framework for the school community gardening project in the spring semester. Since the program ended in January, we were unable to follow through on this important part of the research. However, we were able to capture the importance of place in the last project of the semester, a natural history project, in which students picked a country on the global map and identified cultural and scientific characteristics of that place. Since three of the Karen students chose Georgia, Burma and Thailand, we were able to focus on how knowledge developed within specific communities using Karen community funds of knowledge about Burma and Thailand, and even Georgia. The Karen pastor also made a presentation to the class on the importance of the Karen national flag to the culture. In this way, the students as a learning community were able to learn about the science and culture of the Karen parents' origin countries as well as that of Georgia. In addition, Connor's grandparents had just returned from a mission trip to Kenya, in which they were guests of a rural Kenyan village for several weeks. Connor chose Kenya as his country of focus and had progressed past the initial stages when his grandparents came to the afterschool program to present their trip. As part of the presentation, Connor presented his natural history project (a binder with various cultural and scientific entries) to the class. Natural history projects enabled students to use written and online resources to answer questions that

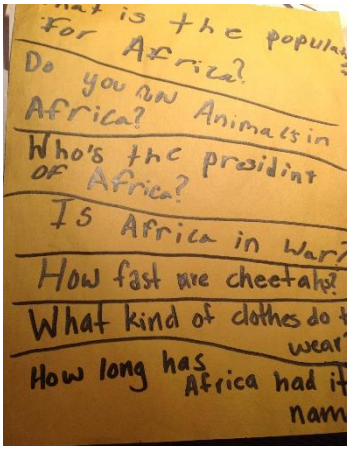


Figure 4 Sample, Student's Questions for Natural History Project

they developed within the larger categories of science and cultural knowledge. Within this one project, they developed literacies in reading, writing, maps, climate, and culture. Students were asked to develop a scientific question based on the geography and climate of a place; for example, Lily's project on the Pacific Ocean featured a question about volcanos based on maps of the area. Each student developed a word search based on the vocabulary they gleaned from children's books on their places. They also engaged with the idea of the politics of place since the children's book on Burma contained references to the civil war.

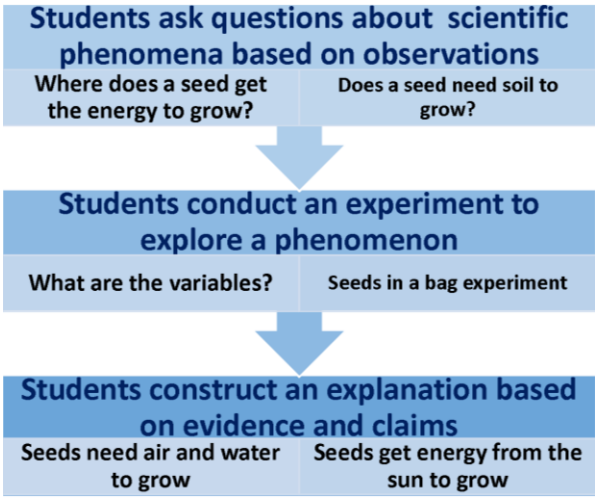
The Afterschool Program: Curriculum Design

Lesson plans (see Appendix D) conformed to reform-based inquiry practices that reflected sensitivity to critical place-based pedagogy and cross-cultural community building. Lesson plans were adapted to the unique sociocultural environment of the students whenever possible, even to the point of incorporating Pokémon, a mythical animated environment appreciated by Karen and non-Karen students. For example, since we did not have access to a stream or a river, but many of the Karen boys said they remembered fishing in Thailand, we used the Pokémon fish creature to talk about how sound travels through water. Explicit teaching of authentic contextualized inquiry-based science (Buxton, 2006) within the guidelines offered by NGSS (Achieve, 2013) involved finding creative ways to decontextualize a science idea in order to allow students to approach it conceptually first before relating it to science. We used children's literature in this way to set the stage for science learning. From the results of phase one, we learned that although Karen children seemed to be fluent in speaking the Sgaw-Karen language (it is their first language at home), no instruction in the written language was

currently being offered (interestingly, the Karen community has recently begun offering a summer camp for Karen children in which they teach the Sgaw-Karen language and aspects of their culture and history). We determined that instruction in the written Sgaw-Karen language would be important to offer in the afterschool program. The Karen co-teacher offered a fifteen minute segment of language instruction for both the Karen and non-Karen students. In order to incorporate embodied Karen and non-Karen science and cultural knowledge into the curriculum, Karen and non-Karen knowledge-keepers from the community were also asked to participate in the afterschool program, both as volunteers and as presenters of specialized knowledge. In addition, we tried to incorporate the history of the Karen people into the curriculum, both through presentations and storytelling by community elders.

The science learning discourse for the community was set in part by the teachers; I adopted the framework of constructing scientific explanations advocated by *What's Your Evidence?: Engaging K-5 Children in Constructing Explanations in Science* (Zembal-Saul & McNeill, 2012).

Figure 5 Model of Constructing Explanations in Science



This discourse fit well with the inquiry-based instructional method and emphasis on NOS that encouraged students to adopt the frame of mind of scientists. The majority of the experiments were taken from *Teaching Science in Elementary & Middle School: A Cognitive and Cultural Approach* (Buxton & Provenzo, 2007). Inquiry-based instruction practices minimized our time in front of the whiteboard. For example, in general, I introduced a science topic under the big science idea of "Energy" and mapped out questions that the students could explore. Once students had a basic understanding of the idea, they were able to propose solutions based on their existing knowledge (for example, the 4th grade non-Karen students had completed a lesson on the phases of the moon and were familiar with the science behind this). Then we performed experiments in small groups or as a large group, recorded our observations and/or data, and created claims based on evidence for the initial problems we had posed. Students were able to agree or dis-agree with the claims, using evidence recorded on the whiteboard or in their science notebooks to support their argument. The following lesson plan illustrates this process:

Week 5 October 2 Physics: Sound Waves

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*]

Sgaw-Karen lesson
10-15 minutes

Review of the Moon Project
http://www.biography.com/people/galileo-9305220
Review of Galileo and how his culture at the time affected his science
Review of data collected.

In a couple of weeks, we will have a storytelling session about the moon. Ask your family for cultural stories about the moon that you can share with the class. Or make up a story about the moon that brings in elements of your family history or culture.

Constructing a Scientific Explanation with Sound Waves

Watch drum videos on PBS:
http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfe.zhanadrum/hanas-japanese-drums/
http://www.pbslearningmedia.org/resource/vtl07.la.rv.text.drums/ancestors-talk-through-drums/

Discuss the cultural significance of music: Why is it important to continue traditions? Who gives us cultural traditions?

Focus Question: How does sound travel?
Strike a drum and a guitar. How does the sound travel to your ears? (sound waves) Have you ever seen waves at the ocean? In a stream? What do waves look like? What causes waves? When we hit the drum or strum the guitar, the **force** disturbs the air around the instrument, causing sound waves. Sound waves carry **energy.**

Claim: Sound travels through waves of energy.
Cover your ears. Can you still hear the drum? Can sound waves travel through obstacles such as your hands? How do sound waves travel? Can they travel in outer space? Why or why not? Why are some sounds high and some sounds low?

Evidence: We can feel the vibrations of the energy being released from the drum. We can hear the sound of the drum and the guitar through our hands and through the wall so we know sound travels through air and some obstacles.

http://www.pbs.org/wnet/musicinstinct/education/lesson-plan-3-good-vibrations/media-resources/119/

Sound Waves and Amplitude
Pass out the slinkys. Once they have settled down, remind them about **stored energy and kinetic energy.** When we move the slinky, what kind of energy travels down the length of the slinky? (kinetic) Where does that energy come from? (your arm) Draw several waves on the board.

Another way to think about waves and how they carry energy is in terms of **amplitude.** A low energy wave (draw on board) has low **amplitude** (draw a line from top of wave to bottom) and a high energy wave has high amplitude (draw a high energy wave on board).

What would a low energy wave look like with your slinky?
What would a high energy wave look like?
What about when PSP sings a high note? What does that energy wave look like?
What about a low note? What does that energy wave look like?

The Afterschool Program: Instructional Strategy

As teachers, we made intentional choices about the power distribution in the afterschool program in order to create space for decolonization to occur. Although this decision became problematic by creating tension for school officials, we designed an instructional space that allowed student participants to move freely around the room and engage at different levels of participation. The purpose was to challenge the traditional power structures of the Western classroom so that students could have a more confident disposition from which to enact agency; for Karen students in particular, who potentially faced a deficit learning environment due to cultural and linguistic marginalization, it seemed important to provide a fear-free environment with very limited behavior modification by the teachers. This decision was a source of tension for the school administrator and teachers, who voiced their disapproval on more than one occasion. For example, the second week we did an experiment with rubber balls to construct a scientific explanation for potential and kinetic energy and to build on the first week's lesson on scientific measurement. We moved into the hallway to conduct this experiment in small groups so that the students had clear wall space upon which to measure the height of their balls. Although there were no other classes or activities going on at that time, teachers who were in their classrooms complained to the administrator about the apparent chaos of the activity. In fact, since the students were responsible for measuring the height of the balls in this experiment, and repeating it three times for accuracy, their energy level was high. One student recorded the measurements on a white board, and after the experiment, we retired back to the classroom to construct a claim based on their observations from the experiment, and discuss supporting evidence. In that experiments of this nature require a

high degree of participation, a certain amount of movement, controlled and uncontrolled, was to be anticipated. Nonetheless, the lesson was successful in that each small group (three Karen girls in one group; two Karen boys and one non-Karen girl in one group; two non-Karen boys in the third group) was able to collect measurements, and, as a large group, we were able to construct a scientific explanation based on observation, claim, evidence and reflection. The following week we re-visited this experiment in order to bring in more precise data: the first time, some students used the inches side of the meter stick to measure the height, and some students used the centimeters side.

To foster a community of adaptive learning for the students, I relied on a community of practice model for phase two of this research (Lave and Wenger, 1991). Through this model of teaching and engagement, teachers, researchers, parents and community leaders could provide scaffolding for science learners to engage in cross-cultural learning and inquiry-based science learning. For this research, it was important for all participants to engage in a group curriculum-building and reflection process that brought in many different voices and perspectives from the communities surrounding the school. This was achieved primarily by bringing in speakers from the community. Although the original design for this research involved critique and reflection by an advisory committee after every afterschool program so that parents, school administrators, experienced teachers and prospective teachers could discuss potential changes to the curriculum before the next session, this format of adaptive management was not possible for this project. Teachers and administrators did drop by the afterschool program but did not participate in structured critique or reflection.

The community of practice model shifts power and authority away from the knowledge experts to the community so that everyone who participates is both science learner and science teacher (Loughran, 2007). This model also stresses the importance of a community time for reflection. The strategy of an inquiry-based science learning program through the curriculum and intentional reflection on NOS at the end of a lesson has proven successful in elementary student conceptualization of key NOS ideas (Quigley, Pongsanon, & Akerson, 2011). In addition, this model could provide a format for explicit teaching and reflection on the cultural knowledge of all student participants. Cultural knowledge would not be the responsibility of the teachers or researcher to integrate, but would rather emerge from a community of learning as the students themselves populated the space with meaning. The chart below illustrates how I was able to situate NOS ideas and inquiry-based science learning within the embodied knowledge of the students.

Chart 1: NOS ideas & inquiry practices embedded within cultural knowledge

Date	Science Lesson	NOS Ideas Covered	Inquiry Activity	NGSS Standards Covered	Cultural Knowledge (Karen language lesson taught by a Karen adult is included in every lesson)
9/4/2014	Introduction to scientific units of measurement	Scientific knowledge is tentative; culturally embedded	Measuring with yardsticks and metersticks	Data collection and analysis (mean, median)	Importance of language in science; Introduction to scientific knowledge (ppt on What is science?), everyday ideas of science and cultural knowledge
9/11/2014	Physics: Potential and Kinetic energy	Scientific knowledge is tentative; empirically based; involves human creativity; culturally embedded; subjective	Constructing a bouncing ball experiment (one ball bounces off another); introduction to simple machines	PS3.A Energy PS3.B Energy Transfer PS3.C Energy & Forces Constructing scientific explanations; building claims based on evidence	Discussion of simple machines was subject to cultural interpretation (jack-in-the-box was familiar to non-Karen students but not to Karen students); use of a dam as an example was subject to previous cultural knowledge; Photovoice project intro
9/18/2014 – 9/25/2014	Physics: Force and Motion	Scientific knowledge involves imagination and creativity; is subjective and culturally embedded	Paper Airplane contest; experiment with adding weight to the paper airplanes	Cause and effect PS3.C Energy & Forces Planning and carrying out investigations; constructing explanations based on evidence	Some of the non-Karen children had experienced flight on an airplane; none of the Karen students remembered this experience
10/2/2014 – 10/16/2014	Physics: Sound Waves	Scientific knowledge is culturally embedded; imaginative and creative; empirically based	Introduction to the moon project; sound traveling through musical instruments; slinky demonstration of amplitude	PS4.1 Wave model	Historical look at Galileo, his culture and how his culture might have affected his scientific discoveries; study on the cultural significance of music: why are cultural traditions important?
10/23/2014-11/6/2014	Earth and Space: Phases of the Moon	Scientific knowledge is culturally embedded; imaginative and creative; empirically based; subject to change	Moon journals; Model of the phases of the moon	Constructing models; S5CS6. Students will question scientific claims and arguments effectively.	Children's literature on cultural beliefs about the moon; why are cultural beliefs important and how are they different from scientific knowledge about the moon? Students write their own stories about the moon, and illustrate them.

11/13/2014 -12/11/2014	The Energy of the Earth: Biomes and Natural History Projects	Scientific knowledge is culturally embedded; subjective; subject to change; empirically based	Natural history of Georgia investigation; development of socio-scientific questions for a place study of a geographical location	3-LS2-1 Ecosystems 3-ESS2-1 Earth's systems 3-ESS3-1 Earth and Human Activity	Students developed natural history projects for one location in the world; these projects took the form of maps, text, and illustrations of scientific and cultural aspects of their place stored in a notebook
1/8/2015	The Energy of the Earth: Climate Change and Hydrology	Scientific knowledge is subject to change; culturally embedded; subjective; involves human imagination and creativity	Designing an experiment: What happens to all the rainwater? Building an Aquifer Model	3-LS2-1 Ecosystems 3-ESS2-1 Earth's systems 3-ESS3-1 Earth and Human Activity Students construct claims and arguments effectively.	Karen students had no idea what a storm drain was; we explored sources of pollution (a culturally based phenomenon) and how they enter the ground water. Students used their knowledge of the earth (derived from gardening at their homes) to build their own aquifers.

Phase Two: Interviews

For phase two of this project, I used a Flip video recorder for interviews instead of an audio recorder. With the Flip video recorder, I was able to capture the expressions and body language of the student participant being interviewed, as well as the group activity behind the student. Students were eager to be interviewed and reminded me if I had not interviewed them yet. I interviewed all of the students individually at the beginning of the program in the back of the classroom during snack time, with the exception of Lucy, who joined the program later. Initial interviews were structured to establish a purpose for the afterschool program and to assess existing knowledge; students were asked about their home and community knowledge. Karen students were asked about any memories they may have had of their lives in Burma or Thailand, particularly with regard to what they remembered about their natural environment there. My experience in interviewing Karen parents led me to believe that the Karen students would open up more in the company of their friends, and this proved to be correct.

Closing interviews took the form of an informal assessment of the science learning identities students had developed by the end of the program. These interviews were conducted with students in groups of two and three, and individually, in the school public hallway and in students' homes. For closing interviews, I used the Nature of Science (NOS) criteria as a way to evaluate how students came to see their role in the production and practice of scientific knowledge through interaction with the program's science learning environment. NOS has been defined as the epistemology of science, the values and beliefs associated with the production and use of scientific knowledge. Many science educators have agreed on the parameters of NOS: Scientific knowledge is

tentative, empirically based, subjective (theory-laden), socially and culturally embedded, and involves human imagination and creativity (Lederman & Lederman, 2012). However, research on NOS in science education has been slow to articulate how culture shapes the epistemology of science, and whose culture is at the forefront of the production of scientific knowledge (Medin & Bang, 2014). Despite extensive work on instructional strategies for communicating NOS ideas to elementary students (e.g. Akerson, Buck, Donelly, Nargund-Joshi, & Weiland, 2011; Akerson, Nargund-Joshi, Weiland, Pongsanon, & Avsar, 2014), little has been done to challenge the assumptions and expectations implicit in predominantly White science classrooms that influence the instruction and understanding of NOS. Therefore this study addressed explicit instruction in culture as a way to approach student understanding of their role in the production and use of scientific knowledge, and NOS critieria were used as a way to measure that understanding. Students were asked the following questions during the final assessment of the program; the questions designed explicitly for NOS are marked accordingly:

1) *Is this statement true or false? You can learn about science at home and at school. If this is true, name 3 ways you can learn about science at home.*
2) *Is this statement true or false? You can learn about your culture and other cultures at home and at school. If this is true, name 3 ways you can learn about culture at school.*
3) *If you could teach a class on culture and science, what topics would be important to include? What scientific questions would you explore? What experiments or models would you include?*
4) *What is the difference between cultural knowledge and scientific knowledge?*(NOS idea: science is empirically-based)
5) *Do you believe that what we know about science changes over time? For example, can our scientific knowledge about the moon change? What would cause it to change?*(NOS idea: tentativeness of science)
6) *Do you believe you will make a scientific discovery in your lifetime? What might you discover?*(NOS: science is tentative; science involves creativity and imagination)

7) *How can your life as a Karen-American/American give you special knowledge to make scientific discoveries that can make the world a better place?*(NOS: science is culturally and socially embedded)
8) *Is it a good idea to learn the Karen language? Why or why not?*

Phase Two: Photovoice

An explicit purpose of phase one was to test the reliability and effectiveness of methods to be used in phase two with Karen students. Since Photovoice was effective in providing insight into the collective narrative of the Karen community, it was the primary method used for phase two. Participants (4^{th} and 5^{th} grade students and the Karen co-teacher) were given disposable digital cameras the second week we met. The Photovoice prompt was modified from "Take photos of people, places and things that have meaning for you" to reflect an emphasis on an understanding of science in their home environment. Students were shown how to operate the cameras; each student had a turn practicing with a sample camera. I gave students the following prompt: Take photos of your culture and science at home. A discussion of the word "culture" followed immediately; students did not understand the meaning of the word. We defined it as a group: games that you play; activities and people that you value; things that you do all the time. We did not define the meaning of "science" in their home lives but left that open for their own interpretation. In two weeks, we held a focus group discussion in which I distributed the photos from their disposable cameras. For this activity, we sat on the floor and each student spread his or her photos out in front of him/her.

The following questions were asked in the focus group:

1) Pick out your favorite photo. What do you see? Why is this one your favorite?
2) Pick out your best science photo. What do you see? Why is this photo important?
3) Pick out your best culture photo. What do you see? Why is this important?

The students sat in a circle with the researcher and each person contributed to the discussion as we went around the circle three times. In order to prompt more reflection from the students, I designed a game in which students closed their eyes and picked a photo from a pile of everyone's photos in the middle of the circle. The student would hold up the photo for the students across the circle to see; then those students had to identify something cultural or scientific in the photo.

Phase Two: Data Analysis

In phase two of this research project, I looked at the effects of building a cross-cultural learning community within an afterschool program on how Karen refugee students accessed science understanding, using agency as an indicator of greater engagement with science inquiry. Theoretically, emerging agency served as the primary marker for the transformative process of decolonization and re-inhabitation of social, political and environmental spaces. According to the state education department statistics for 2014, the total student population of the rural elementary school that hosted this project was 74% White, with 8.8% Asian population. Teachers and administrators at the elementary school where this study took place were representative of the dominant culture: White and primarily women. Therefore, a classroom at a public elementary school was an appropriate site for decolonization to occur. Historically education in economically-underdeveloped countries, such as Burma and Thailand, has relied upon unquestioning obedience to the teacher, a pedagogical distinction that could disable students trying to form a well-constructed scientific argument in the classroom. Therefore, contextually authentic science learning for culturally-diverse elementary students has relied upon teacher-mediated approaches such as funds of knowledge or

instructional congruence to infuse the science classroom with culturally-appropriate ways of knowing. While decolonization of a science classroom has not been prevalent in research with culturally-marginalized students, it was appropriate for this research. In ways that are discussed in more detail in the section on limitations, this afterschool program was "displaced" within the physical and academic space of the elementary school classroom.

Decolonization of our learning space occurred in three ways: 1) first we decolonized the physical space of science learning by disrupting the established protocol of students seated at desks facing the teacher at the whiteboard; we, teachers and students, sat on a woven mat on the floor in a circle; 2) we decolonized the cultural space of science learning through the Photovoice exercise by allowing space for students to create their own cultural discourses; and 3) we decolonized science learning by situating inquiry science investigations within the students' cultural and experiential spaces and by employing scientific practices that allowed students to act as producers of scientific knowledge. The vehicle for the re-inhabitation of our science learning space was the cross-cultural learning community, a venue that allowed teachers to act as learners with students in the process of scientific discovery. Freire (1970, p. 79) referred to educators as cognitive actors engaging in the process of critical thinking together with students, as opposed to the banking model of education in which the teacher serves as a receptacle of expert knowledge. In order for liberating education to occur, the teacher must engage in a dialogical process of reasoning with students, and eschew the power that comes from occupying a position of superior knowledge (p. 80). We teachers and students as a learning community tried to re-inhabit our learning space so that the construction of

embodied science knowledge within the framework of cultural knowledge could make the culture of science accessible to all participating students. This involved a process of "de-settling" expectations for science knowledge (Bang, et al, 2012), namely that scientific knowledge can emerge only from the community of practice of scholars and should be taught from textbooks as decontextualized knowledge. Instead, this project opened the door to indigenous knowledge, or "multi-science" (Hammond, 2001), rooted in the present and past narratives of a place and a non-dominant people. Participants were asked to make sense of their own culture at the same time that they conducted science inquiry investigations; the line between culture and science thus became more

In phase two, video recordings comprised the majority of data collected. Transcribed video recordings were analyzed through thematic narrative analysis (Riessman, 2008), looking for pieces to the narrative whole and unexpected insights (Derry, et al. 2010). All of the videos were transcribed and analyzed: recorded hours of class time in addition to video recordings of individual and group student interviews. The video transcriptions served to verify the researcher's field notes recorded in her reflective journal. One limitation of relying on videotaping for the primary source of data was the dual role both teachers had to play during the afterschool program. Mary and I took turns videotaping the class activities when the other was teaching. However, at times both teachers were fully engaged in class activities and could not spare time to videotape the class.

Phase Two: Narrative Portraits

Narrative portraits were constructed with all of the student participants. To facilitate this task, I kept a reflective journal on all of the afterschool programs. In

addition, I conducted semi-structured interviews with the student participants both at the beginning of the school year and at the end to try to determine if the students had experienced a shift in their thinking about everyday science knowledge, Nature of Science (NOS) ideas and the connection of their culture to science learning. Participant observation with semi-structured interviews, Photovoice, and the narrative portraits provided triangulation for reliability. Two summative assessments were administered, one for the Karen lessons at the end of the fall semester, and one at the end of four inquiry-based explorations. Both summative assessments were short answer quizzes in which the teacher asked a question and students wrote responses on a sheet of paper. The science inquiry assessment was based on lessons learned collectively in the science portion of the afterschool program, and was administered in English. The second assessment was based on the Karen language lessons and was administered in English. Neither of the tests were graded but all were checked for accuracy. Alternative assessments were offered through multiple opportunities to participate in arts-based responses in addition to written responses. Opportunities for creative imaginative speculation about science and the world were offered generally, and specifically during the moon lesson. All of the data was analyzed collaboratively with the Karen co-teacher to ensure accuracy.

Limitations

The limitations for this research, touched on in previous parts of this report but addressed in their entirety here, could be divided into three parts: limitations with the site; limitations with the participants; and limitations with the activities.

Limitations with the Site

Although teachers and administrators for the research site initially endorsed the research design for this project, they progressively isolated it from the larger context of the school, and eventually cancelled access to the site altogether before the research was completed. Although other reasons were given for prematurely cancelling access to the site, I believe the principal, under the influence of the district representative responsible for research in the county schools, became increasingly anxious about our presence in the school, and welcomed an opportunity to refuse us access to school property. Many factors may have contributed to this final decision; because the principal refused to meet with me to discuss issues that had arisen (she communicated only through emails, in which the district representative was copied), I can only speculate about the source of her anxiety. My contact with the principal dates back several years; my husband and I knew her through relationships at church. In fact, I selected her school because she represented herself in the larger Athens community as very forward-thinking, and as an advocate for equity in education. I began conversation with the principal two years in advance of the project date. At that point, she was interested and even excited about my research idea and the relationship I was establishing with Karen refugees in the community around her school. Over the next two years, I continued conversation with the principal and teachers who were training in ESOL, and volunteered in an afterschool program for Karen elementary students that was funded by the school district. I also volunteered at a summer camp for Karen students sponsored by the school. In preparation for my research project on site at their school, I put together a three-lesson plan series and conducted it on a trial basis the preceding spring in April. The principal and teachers

approved the lesson plans and supervised in part the trial implementation, which did not involve any data collection. My project began the following fall. The discord originated over where I was parking my car in order to unload all of the materials that I brought for the program. I was parking in a dirt lot where other teachers parked, and I was directed to move to the visitors' area. For me, this discord seemed disproportionately energetic. It should have indicated a climate of unsettledness if not hostility, which I could have worked harder to repair, but instead it seemed like an anomaly. Other incidents occurred over the fall that seemed like harassment but were also indicators of an increasingly distressful environment. These incidents culminated in an alleged accident in the classroom in which a smartboard was damaged; although the incident occurred before my program was scheduled to begin (I was unloading materials from the car at the time), I was held responsible.

One possible explanation for the deterioration of what I thought began as a collaboration for achieving the common goal of increasing educational opportunities for Karen students would be that my research design was too unfettered by school control. By establishing a learning community rather than conforming to the more traditional didactic form of instruction, I may have given the appearance of a lack of control in the classroom. Although we did have to deal with aberrant behavior that sometimes flagged our energy, this was to be expected with a re-distribution of power in the classroom. In addition, by decolonizing the existing power structure in the classroom (sitting on the floor with our shoes off; instruction given in a more informal style using a portable whiteboard) and privileging the Karen culture, we may also have given the impression that we were not in control of the students. However, in the same way that the learning

objectives for scientific inquiry and instruction in NOS have veered away from didactic instruction (drilling students for the "right" answer) toward a more critical approach, so our instructional strategy was designed to promote agency in the students, agency for constructing cultural knowledge, and agency in science learning. Without complete collaboration with the principal and teachers through an advisory committee, which was part of the original research design, there was not a mechanism in place through which they could express their concern. The advisory committee that was originally planned for this research would also have been composed of parents, who could contribute their funds of knowledge, so that the afterschool program could be managed adaptively to achieve the learning objectives of many different stakeholders. Since the advisory committee was vetoed in the fall at the recommendation of the district representative, our program became isolated from the school, and communication was sacrificed.

Limitations with Cross-Cultural Research

Another limitation that had a critical impact on this research was the lack of adult participants in the afterschool program. In addition to the advisory committee, I had imagined that we would have at least one other Karen adult helping with the videotaping. Since adult participation was limited to myself and Mary, all of the unloading of materials from the car, setting up materials in the borrowed classroom (we were not invited to use any of the resources there), interviewing, videotaping, teaching and facilitating inquiry projects, was limited to us as well. As a result, I found that I was in the middle of an inquiry project rather than behind a video camera when the most significant events for the research occurred. Mary and I took turns videotaping when the other was teaching, but the inquiry projects required all of our attention if they were to be

conducted well. At times one of the students, Lucy, helped with the videotaping, and Brad also took a turn behind the camera, but these were more supervised exercises in developing agency than opportunities for recording research events. The lack of Karen adult participation also placed the full weight of representing embodied knowledge on Mary. At one point, as reflected here in my journal, it seemed to become an overwhelming task for her:

> *We need to stop going in by the side door – Dr. R had us come in to the front and sign in as visitors (for the first time). The beginning of our program is still too chaotic; with one of us up front signing in, the kids are too unsupervised. In fact, I think I might send out a call for help to see if we can recruit a parent volunteer. Particularly now that I am trying to videotape the sessions, it would be helpful to have extra adult hands. PSP tried to do that yesterday and was quickly fatigued. She and EK have been going to intensive GED classes at Athens Tech and it has exhausted her. She did a language lesson yesterday but then I think her head really started aching.* (excerpt, October 9, 2014)

I believe if this afterschool program had had more support from the school, rather than incidents to assert control that ended up disrupting the program, and more support from the parents in the form of volunteers and an advisory committee, the tasks of implementing the lesson plans and recording data for the research would not have been so overwhelming.

Limitations with Activities

Finally, a severe limitation that reduced the impact of this research, I believe, was the inability to advance to the school garden project. Originally the centerpiece of this research project, the school garden was sanctioned by school authorities before the fall, and a site for the garden had been established. Interestingly, we were just beginning to venture outside to collect soil samples from the garden site when the program was discontinued. Although the learning community took time to achieve a climate of

reciprocity, by the end of the fall semester, we had worked through most of the behavior issues and students were excited about designing a garden at the school. This part of the research had great potential, both for bringing Karen parents on site to the school, which was extremely challenging, and for allowing Karen students to move to the center of learning by leveraging their family and community funds of knowledge. As discussed in the results section for phase one, gardening was determined to be a sentinel keystone characteristic for the Karen community, one that could sustain cultural resilience for Karen adults in a time of great disturbance. It would have been interesting to determine whether or not Karen students appropriated the cultural importance of gardening for their own hybrid identity.

Conclusion

In this chapter I outlined my action research design and identified Photovoice as the primary methodology used. I justified the use of Photovoice for this research with a literature review citing relevant cases in which Photovoice contributed to an emancipatory research framework with vulnerable study populations. In addition, I outlined the use of crystallization to create a multi-genre representational space for this research, and identified narrative portraits as the centerpiece of this approach. I justified the use of crystallization and narrative portraits with a short literature review of relevant studies in which vulnerable populations benefitted from space in which they could co-author their own representation to the public. Providing multiple venues for self-generated representation has been shown to increase resilience in vulnerable populations. They are able to represent themselves as agents working for positive change rather than passive figures objectified on the periphery. In addition to graphic representations of

both phases of this research study, this chapter also highlighted the methods used to gather/generate data, with attention to the value of visual ethnography when working collaboratively with vulnerable populations. In the same way, arts-based methods such as narrative portraits allowed me to paint a broader, more subjective representation of the participants than quantitative methods and analysis would have. This chapter also included a rich description of the afterschool program I designed with Karen parents. The afterschool program served as the vehicle for this study; in itself, it was the setting for research rather than the focus. In the following chapter, I discuss the findings from both phases of this research project, with Karen parents and with Karen students.

CHAPTER 4

Findings: Action Research with Karen Parents and Students

The purpose of this research study was two-fold: 1) to allow Karen parents in a small rural community to represent their own culture in a public forum by identifying what cultural knowledge they would like their children to retain as they transition into the U.S. educational system; and 2) to explore how that knowledge could be leveraged within a cross-cultural learning community for 4th and 5th grade students to advance Karen students in science learning. To facilitate this research, I partnered with Karen parents to design curriculum for and teach in an afterschool science and culture program at a local elementary school in which Karen students and parents were a minority population. In Phase One, I worked with Karen parents to explore the key characteristics of cultural and scientific knowledge they identified as essential to the sustainability of their culture in resettlement. The following questions guided this part of the study: What key aspects of their culture do Karen parents identify as critical to the healthy development of their children's cultural identity as Karen Americans? Of those, which aspects contain the most potential to contribute to a cross-cultural science learning community for Karen students? For Phase Two, I co-taught Karen and non-Karen students in a science afterschool program outlined above. The following questions guided this portion of the study:

1) How does the construction of a cross-cultural learning community that privileges Karen cultural knowledge affect the science learning of Karen student participants?

2) How does the presence of Karen cultural knowledge represented by a Karen co-teacher and the Karen language affect how students position themselves within the learning community?

This chapter explores the findings from phase one, a qualitative study with Karen parents, and phase two, a qualitative study with Karen elementary students. Karen parents (summer 2013) and students in the afterschool program (fall 2014) constructed visual narratives through Photovoice; these visual narratives were woven into narrative portraits. Narrative portraits of the participants appear at intervals in this chapter to illustrate the deeply contextualized nature of each participant's production of knowledge through interaction with his/her learning environment and community. Narrative portraits also created a broader base for participants' self-representation. The social and cultural terrain revealed by narrative portraits served to de-objectify the participants by weaving their stories into that of the community. This chapter begins with identification of the themes that emerged from narrative analysis of phase one with Karen parents, followed by thematic analysis of phase two set in the afterschool program.

Phase One: A Counter-Narrative Emerges with Karen Adults

> *One of the advantages of having such a strong community here, Hgaw tells me, is that they can pass their values on to their children. The children can learn about the values that sustained the Karen people through decades of civil war and internment, and that keeps them together now in resettlement. It is important, he agrees, for the children to understand their parents' values, both through Christian education and through other forms of education. If they value their own culture in addition to the culture of their new country, then they might find balance and wholeness in their lives.* (excerpt from a narrative portrait of Hgaw, a Karen father)

The narrative constructed by Karen participants for their cultural identity in Burma and in the camps acted as a counter-narrative to the collective identity imposed upon Karen people in Burma. The following narratives demonstrate the demands being made of them

with regard to the government's expectation of conformity to a cultural identity institutionalized through centralized education and enforced by military action. By contrast, the community narrative they constructed here situates them as dynamic actors in the shaping of their own futures and the futures of their children, agents for transformation rather than victims of senseless violence and displacement. Narrative analysis revealed the knowledge domains of education, religion, language, Karen history, and a cultural anchoring in the land identified in the participants' written and visual narratives as cultural knowledge. Community narratives seemed to anchor individual families in social memories that tied them to their lives in Burma, memories that were populated with meaning beyond the violence and destruction. Participants were able to re-capture a collective cultural identity through the liberating discourses of education and Christianity that set them apart from the dehumanizing identity imposed on them by state authorities in Burma and Thailand. This collective identity seemed to carry more weight in this first-generation refugee community than individual narratives. The visual narratives collected through Photovoice focused almost exclusively on plants, livestock and family. More than the written narratives, the photos provided insight into the cultural and social capital of individual families. The following chart lists the domains of knowledge, referred to in this project as keystone cultural characteristics, and the themes that emerged from these domains:

Education	**the power of education to provide opportunities for a better life**
Christianity	**serves as a primary component of the Karen counter-narrative; connection to Karen State and to communities in the United States; a tool for shaping identity**

Language	**serves as a primary component of the Karen counter-narrative; connection to Karen State and Karen people still in refugee camps in Thailand**
Karen history	**preserves Karen culture for the children; passed down in oral form; connection to Karen State**
Farming	**serves as a source of autonomy and self-determination; tool for collective and individual identity shaping**

Chart 2 Knowledge Domains for Phase One

Of these narrative themes three key themes emerged out of these domains: 1) the power of education to transform Karen lives; 2) the cultural importance of maintaining the Karen Christian community as a source of identity; and 3) the role that gardening serves to anchor Karen adults to the land, to a physical sense of belonging, and to a future enlightened by self-determination. Each theme crossed several domains, and in the case of education and Christianity, the latter was embedded in the former. For the purpose of narrowing in on the knowledge domains that most particularly apply to science education, this section highlights findings correlated to education and gardening. These domains of knowledge served as keystone cultural characteristics, sentinels of cultural identity that were incorporated into a cross-cultural science learning community for Karen students.

Although instruction in Karen history was also identified by the participants as essential to the survival of their culture, there was little evidence to support the idea that it carried equal weight for rebuilding cultural resilience as other characteristics. Even though national days such as the Karen New Year were honored by families, more importance seemed to be attached to faith-based community gatherings. One possible explanation for this could be the lack of a need for a strong narrative of nationalism as they try to integrate into the social infrastructure in the U.S. In the same way, although

the Karen language is undoubtedly the primary language of Karen households in this community, Karen parents did not have a formal structure set up to teach their children to read and write in that language before this research began. Their emphasis was on learning to read and write English more efficiently. However, in the past two summers, Karen parents have established a summer camp for Karen children in which they teach the Karen language and other aspects of the Karen culture.

Working the Land: Anchoring Karen Adults to the Past, Present, and Future

Gardening for the Karen participants seemed to hold cultural meaning beyond the ability to establish a self-sustaining lifestyle. The garden represented a bank of cultural knowledge that tied participants to their lives in Karen State in Burma. Although gardens were impossible to sustain in the limited space of the refugee camps, many narratives contained references to gardens and livestock in Burma. One participant remembered all of the fruit trees that were planted at his village in Burma, and the goat that provided milk for his family. Another participant remembered that her family traveled with a water buffalo, but they were too transient to sustain a garden. In referring to their lives in the United States, although most participants did not speak at length about the importance of gardening, all of them took between ten and twenty photos of their gardens and livestock during their Photovoice sessions. One participant took the iPad directly out into her host's garden to take multiple photos of the plants and the chickens pecking around the yard, and then took at least ten more at the community garden. The majority of the photos taken by all of the couples focused on the plants and animals the families were cultivating, with photos of immediate and extended family members represented slightly less.

Farming linked family autonomy and the Karen collective identity for the Karen people in resettlement. Families divided their free time between working at home in their gardens, working at the community garden, and visiting with one another. Food grown in the Karen family gardens represented an independent lifestyle, the choice to invest time and energy in long-term sustainable practices that gave them a margin of freedom from dependence on the state. Farming also contributed to the collective social narrative by defining the Karen people as generous, more predisposed to sacrifice the gain of the individual for the good of the community and even the nation. In the following narrative, farming was presented as a way to not only preserve the Karen cultural identity in the U.S., but also as a means of restoring national health and self-determination to the people of Karen State:

> Yea, that's why, yea, I think it is very important that, now because the war changed very quick, for the Karen people it is very important that they have to think ahead that in our country, in our motherland, it is not science but someday it should be a science there we have to go back and teach them. If we don't do that, maybe later there is no food they will be starved. So we would just like to preserve those. Yea, it is very important for them to do now. And also they need to combine the way they did, yea, the science, the nature that they learn from, yea, if they know how to combine, I think maybe we will be always have the, just like have the food, always have the food. Yea, I think very important in the United States. I worry a lot for my kids, when they grow up in the United States. The reason why I worry a lot it mean all the stuff I buy from the Walmart or anywhere come far far away from China! (*Joseph, interpreter and Karen father, interview*)

Fig. 6 Joseph, one of the translators and a Karen father, stands in front of his house, a symbol of his life here, and next to a banana tree, which symbolizes his life in Burma.

Livestock and the plants in their gardens not only contributed to the collective cultural identity, as seen above, but they also represented the wealth of the community, distributed through the practices of hospitality. An icon of their culture, hospitality for this Karen community meant hosting community events and church events in their homes; serving food whenever a visitor arrives at their house and sending fresh vegetables home with them; and taking the time to visit friends and family whenever possible.The community garden functioned as a community center, a social space like their homes where Karen families from the city gathered with friends in the country. One participant selected a photo of the community garden out of the batch of photos spread out on the floor during the Photovoice focus group discussion. "Our Karen people," she said through the translator, "like to plant and have a garden, so when we were in Thailand, then we come here and we're doing the same thing that we did in Thailand. It helps me remember my home, Karen State." Participants planted Roselle, tomatoes, squash, bitter melon, purple beans, pumpkin, and banana trees in the community garden using seeds from Thailand whenever possible. The chickens came from Cuba and Thailand, one of the participants told me during a visit to the livestock section of the community garden, where a few brightly plumed roosters lorded over a hundred less brightly plumed chickens. This space was not only safe, it was familiar territory.

In its capacity as a community center, the community garden provided a space where the participants constructed their blended Karen American culture as a social group. Karen people gardened with their hands and with tools as they were available; one man waved to me from a tractor he had borrowed from the adjoining farm. Modern farming tools were not available in the rural regions of Burma. When I visited the Karen

community garden one Saturday morning with one of the participants, a small group of Karen adults welcomed me and offered me a bag of vegetables harvested that morning. Some men were gathered around a fire supporting a large pot of boiling water. They were preparing to slaughter a pig. One of the men approached me about finding a place to fix a crack across the face of his iPad. Startled, I found myself caught in a time vortex between the culture of their past and the culture of their present. The garden had a Karen name that translated into "Neighbor's Field" and was sustained by a water system funded by a local Episcopal church. It was a safe physical place in which they produced social memories. Those memories in turn anchored them in a climate of belonging rather than invisibility or fear (Eastmond, 2007). One participant expressed this thought during the focus group discussion: "As a human on this planet, we need to belong to something. If we don't have a home or belong anywhere it seems like we don't belong to this planet."

Education as a Symbol of Freedom

As a symbol of freedom and empowerment in several of the narratives, education was linked closely to a collective Karen cultural identity. All of the participants spoke about their education in Burma and Thailand, even if it was negligible. Although state-sanctioned education was available in high-population areas such as the Irrawaddy Delta at the southern tip of Burma, education in Karen State along the border of Thailand and in other more rural districts was not universally available. One participant indicated that while he grew up in Rangoon in the delta area of Burma, his wife grew up in a more rural area. Because she traveled with her father to help support the family, she did not have the opportunity to go to school at all. When she was nine years old, she and her father moved to Thailand to work in a pineapple plantation. Eventually, as a young woman, she

attended a Bible school in Thailand and met her husband there. He lived for ten years in a refugee camp in Thailand, Tae Min. After exhausting the limited education available in the camp for languages- Burmese, Karen and English- geography, math and some natural history, he escaped the confines of the camp at night to study theology at a nearby Bible School. He served as a pastor in the refugee camp and has continued in that capacity in resettlement. He and his wife have developed a Christian education program for Karen children here in the U.S. However, during the interview, she allowed him to speak for her, and insisted she did not have enough education to talk about science or contribute to the afterschool program.

Education in Burma was linked tightly with religion to form the body of the collective Karen identity. According to one narrative, Christian Karen people were persecuted and killed in Burma because they were seen to be more educated. One of the participants spoke at length about his mother, a Christian evangelist in Burma, whose movements were restricted because she was perceived to be an educator by the Burmese military. His mother was trying to cross from the white zone in Burma, a geographical area in which all citizens were physically safe but lived under the tight control of the government, into the mixed brown and black zone, an area in which some people lived safely under the protection of the army but had to support the army with food and supplies, and other people were vulnerable to random attack.

> My mother was from the white zone. If you grew up in the white zone, you are Karen. But your ID say you are Burmese. She visit her parent and then she was threatened you cannot go there, why you go over there? If you need here or you don't survive, why not live in the white zone? You will survive. You think you will die, you will die in the white zone? Why don't you go to the brown, black zone there? Go to the Karen State there. My mother said I go just to preach. No, they said, I know you are not only preaching, you go and teach the Karen people to be educated, right? Then they threatened my mother a lot, like they fire on my

> mother come back, they kill my mother, and also they try to arrest my grandparent and then they put them into prison because my mother was here. (*Joseph, interview*)

Although education for Karen people who practiced Buddhism was sanctioned by the government, education for Christians was not. Buddhist education was not perceived to be a threat to the government. Joseph continued:

> But the Karen Buddhist, because the thing, they are Buddhist, this people are Karen people, this is no their people, so they don't like them either. But they like them better than Christian because the same religion. That's why they give them a little bit more freedom. More freedom, I don't say freedom, but like safer, like safer. (*Joseph, Interview)*

Education for Christian Karen people, by contrast, was perceived to provide a social infrastructure for an ideology of liberation from the Burmese military dictatorship. As a result, an infrastructure for the education of Christian Karen children was not provided by the state.

> Yea, when I was in Burma, there is no school. The Karen State, the Burmese government doesn't want the Karen people educated so there is no school in the region where I grew up. But we have our own school there, we call *Go Htoo Go Thai* in Burmese language just like sets apart, just like family gather together, each village gather together, then they put money together, they put energy together and they try to build a small school, just like primary school for the kids and then they pay them with rice, they don't pay them with money, they don't have money, maybe just for the teacher, they pay them every monthly or yearly, they give them rice for them to survive, for the whole family to survive. And then they give them just like animal, rice only, they have to pay the teacher. And not just only education freedom even though the religion you don't have freedom. If you are Christian, you are more likely 80% at risk. If you are Buddhist you are 50% more freedom, yea, you a little bit safer. If you are Christian, you are a little bit danger. (*Joseph, interview)*

Although Christian education and state-sanctioned and funded education are distinct in the United States, this did not hold true for Burma. Under the military regime, religion and education were inextricably combined, even though the education might consist of non-religious subjects such as English and the Burmese language. In a sense, the dual

discourse of Christianity and education provided a counter-narrative to the narrative of the Burmese government. The military government sanctioned citizenship demarcated by Buddhism, education conducted in the Burmese language, and membership in the Burmese ethnic majority. By constructing a counter-narrative, Christian Karen people were able to create a cultural identity distinct from that sanctioned by the government.

> Yes, I was born in Burma, in the Karen State, that we try to fight for, but our state name called Kaw-Thoo-Lay. Kaw Thoo Lay mean Land Without Evil. So we want our country name Kaw Thoo Lay. But the Burmese hate that. They don't want that. Land Without Evil mean just like everybody all there are pure, just like the idea of just like Christianity but uh the Burmese doesn't want to do that because they want this country to be a Buddhist country, one nation, one religious, one language, so they hate it a lot, that they just like, just like, they fear us, they will become all Christian. The most that they want to persecute on the Karen people because they fear that all the Karen will become Christian because we don't accept their Buddhism. That's why we don't have a chance to call our country name like Kaw Thoo Lay, Land Without Evil, but most people know it as the Karen State, just for only the Burma, the Burmese people, they know it as the Karen State but they don't know Kaw Thoo Lay. (*Joseph, interview)*

In resettlement, participants recognized the individual freedoms that citizenship in the U.S. gave them but held tightly to the Karen counter-narrative of loyalty to Karen State and their Christian faith as expressed through traditional Karen services of worship and community events. Tension was evident throughout the narratives between the need to belong to the Karen culture that existed in Burma before they left and a need to belong to the culture in their new country. The social memory of the Karen families they left behind in the Thai refugee camps was still a fresh and essential part of their cultural identity.

Moreover, their view of education had not changed dramatically: in resettlement as in Burma, education was still strongly associated with individual and collective freedom. Education in the United States provided a social infrastructure for liberation

through citizenship, job advancement, financial security, and the promise of vocational fulfillment and civil rights for Karen children according to several narratives. Participants identified the task of learning the English language as the most profound barrier to achieving a level of economic and social capital. Although English was identified by all of the participants who attended school in Burma and Thailand as one of the subjects taught at the primary school level, many of the adults experienced interrupted or no education due to the climate of war. One of the participants identified an issue with teacher retention in the refugee camps:

> "When American opened the way to uh feel to come to the U.S. so many people come they look at the vocation to study more so they left the job and they find new way and they came to the U.S.A., so the school left there, they most people they don't have the I.D. so they can't come to American so after they grade ten, they have to uh teach the student. So they have less education, yes."

Another participant said that he would eventually like to return to school so that he could work somewhere other than the chicken processing plant, but for now, he considered it his duty to his people to remain there so that he could navigate the language and cultural barriers for his fellow Karen workers. During the interviews, participants spoke limited English and communicated almost exclusively in Sgaw-Karen with each other and with their children.

When asked directly about an afterschool science program for Karen children, all of the participants endorsed the idea as a way to develop academic opportunities for their children. In the focus group discussion, one woman selected a photo of her children lined up on a couch. She spoke clearly in Sgaw-Karen, which was then translated: "We came to the U.S. because of our kids. We want them to become a famous person and get education and then later can lead our nation, Karen State." The Karen woman who served

as translator stated clearly that the pursuit of higher education motivated her to tackle the challenges of resettlement. In the Photovoice focus group discussion, one man selected a photo of a community celebration, and commented, "Before, we lived in a rural area. We cannot see foreigner and foreigner cannot see us. Now we are the same level with everybody even though we are from the place where nobody knows. We are refugee. This photo represents all color: black, white, yellow, everything are the same. And me, American." Another couple selected a photo of me standing in their family garden. She said, "You are the first white person who has visited my house. When we move here, we don't have many people visiting us before."

A key to this research project with the Karen community was the development of relationship that emerged when a clear shared objective was established: in this case, the creation of a sustainable afterschool science education program for the Karen children. This objective opened doors to Karen homes, community agencies, and the local elementary school and allowed the researcher to establish a level of reciprocity in learning that would not have been possible otherwise. By working collaboratively with Karen adults to glean knowledge about science and education as well as the keystone characteristics of their culture, I was able to cultivate respect for their cultural heritage and ways of producing embodied knowledge. Through working collaboratively with the principal and ESOL teachers of the local elementary school in the development of a culturally-responsive pedagogy for an afterschool science program, I was able to cultivate respect for the school's ways of producing knowledge. The end goal was to pull all of these streams of knowledge together into a science curriculum and instructional strategy that honored the cultural heritage and language of the Karen people.

Phase Two: Karen Students Shape Cultural and Science Learning Identities within a Cross-Cultural Learning Community

Narrative analysis revealed a distinctive pattern of emerging agency on the part of Karen students both in the construction and maintenance of a science learning space within the cross-cultural learning community. This space shaped social and academic interaction among participants and facilitated the construction of cultural and scientific knowledge. In terms of the three-dimensional frame suggested by Clandinin and Connelly (2000), spaces for interaction were defined by how students positioned themselves socially within the community of learning. Students who entered the experience with high social and/or academic confidence were compared to those who entered with an average amount of confidence, and further to those who entered with very little social and/or academic confidence.

Students	Social position	Academic position
Connor (non-Karen)	Maintained high social confidence and extended it to cross-cultural community	High academic confidence declined to medium
Tommy (non-Karen)	Maintained low social confidence	Low academic confidence increased to medium
Sally (non-Karen)	Low social confidence increased slightly	Maintained high academic confidence
Lily (Karen)	Maintained high social confidence	Advanced from med-low academic confidence to high
James (Karen)	Maintained high social confidence and extended it to cross-cultural community	Maintained high academic confidence
Brad (Karen)	Maintained high social confidence and extended it to cross-cultural community	Low academic confidence increased to medium-high
Chris (Karen)	Low social confidence increased to medium	Low academic confidence beginning to increase
Hannah (Karen)	Maintained low social confidence	Maintained low academic confidence
Lucy (Karen)	Low social confidence increased to medium	Medium academic confidence increased to high

Chart 3 Social and Academic Positioning of Student Participants

Categories emerged that defined students' actions and discourses in terms of social and academic position within the community:

1) Those students whose social and/or academic position did not seem to change in notable ways over the course of the project;

2) Those students whose social and/or academic position within the community changed in major ways over the course of the project; and

3) Those students who experienced what seemed to be minor shifts in academic and/or social position within the community over the course of the project.

Within these categories, any change in social or academic positioning over time was flagged as a possible indicator of emerging agency which could in turn lead to insight as to how students negotiated for agency within the group and the funds of knowledge they leveraged to do so. Social position was defined in terms of how the student interacted with students and teachers within the learning community; for example, Connor entered the program with a high level of academic and social confidence. He talked openly and often within the group about his academic achievements and seemed to expect a disproportionate amount of the teachers' attention. In addition, he acted out on occasion to capture the attention of the learning community. By contrast, Tommy would often sit at the back of the learning circle, frequently with his hood pulled up over his head, and he did not contribute to the general discussion unless pressed to do so by students and/or teachers. Academic position was defined by the student's actions and words within the context of the language and science lessons. The narrative portrait below illustrates how a gradual positive change in academic and social positioning by two Karen students precipitated a positive shift toward engagement with science learning. One of the Karen students, Lucy, began the program with very little apparent social confidence; she was

quiet and did not compete with the other students to contribute to the learning discourse. However, when she was placed in a position of leadership during one of the modeling exercises, she advanced to a position of agency in science learning, and challenged one of the non-Karen students in a structured argument.

Lucy and Hannah were always in a small group with Lily unless you separated them. Lily's social fearlessness gave them courage, I believe, at the beginning of the program. Unlike Lily, Lucy and Hannah were shy, almost withdrawn. With Lucy, this developed into a quiet confidence. For Hannah, the shyness lingered until the end. Although at the Karen Christmas celebration, Hannah was racing around in flip flops in the freezing rain, and plainly having a great time! I will always remember her bright wet face smiling up at Mark and myself as we trekked along from the church to the wide field where Karen children were running everywhere in groups, laughing and trying to climb a greased pole to claim the $20 prize at the top. Lucy was our teachers' surprise at the end of the program; she blossomed as a science learner who could focus on the problem at hand and try different approaches until she was satisfied with the result. She was the teachers' helper, distributing snack for us so that all of the students, even the late-comers in Fit Club, could have something. She watched James to make sure he didn't put handfuls of the pineapple candies away in his pockets. During game time and group learning, Lucy and Hannah were not the first to call out answers or volunteer for responsibility, but when they focused on a project, like the aquifer project, they gave it their full attention and expected to discover something amazing! (Narrative Portrait, Lucy and Hannah)

Based on the discourses and shifts in social/academic positions students adopted in the afterschool program, the following themes emerged from narrative analysis:

1) Karen and non-Karen students leveraged peer and family funds of knowledge to create their own hybrid learning space based on the understanding they gained of their own culture;

2) Karen students leveraged their family knowledge of the Karen language to change their social and academic status within the cross-cultural learning community;

3) Karen students leveraged cultural knowledge to engage in scientific inquiry within the cross-cultural learning community with a higher level of agency by the end of the program.

This chapter is composed of a rich description of how the participants constructed knowledge within a learning community and the nature of that knowledge, specifically how participants accessed discourses within the community in order to construct knowledge and legitimate it, and how participants leveraged that knowledge in order to gain agency. It is divided into three sections:

1) Cultural knowledge production by the community;
2) Scientific knowledge production by the community; and
3) Evidence of emerging agency in science learning.

Cultural Knowledge Production

In order to allow the Karen students to construct their own hybrid cultural space, pulling cultural threads from their home culture, their community culture, their school culture, and even their culture of play, wide boundaries for the interpretation of cultural knowledge had to be set within the group. The Karen culture was made legible in three primary ways: through the Photovoice exercise; through the Karen language lessons; and through the presence of the Karen teacher. When we began the program, neither the Karen students nor the non-Karen students understood the meaning of *culture.* Students articulated cultural knowledge during the Photovoice exercise at the beginning of the afterschool program when they were asked in the focus group discussion to identify cultural and scientific characteristics of their photos. This section includes a description of that discussion and the cultural discourses constructed within the exercise that made

students' cultural knowledge legible. Structuring the Karen language lesson into the curriculum for fifteen minutes of every session of the afterschool program gave the Karen culture legibility as well as credibility for all student participants acting within the decolonized school cultural space. Karen and non-Karen students were able to access this literacy in the same way that they accessed literacy in science learning, through the cross-cultural learning community. This section also includes a discussion of the language lesson and the role of the Karen teacher in embodying Karen cultural knowledge.

The Karen teacher believed with conviction that Karen children should learn their home language. In my closing interview with her, she talked about a song from the Karen tradition that addressed this concern. The words of the song warned that if the Karen people did not love their language, the people would be gone someday. When I asked the non-Karen students in their closing interview if they thought learning the Karen language was valuable, all three did not hesitate to say it was valuable. When I asked them to elaborate, two specified that they wanted to learn the Karen language so that if they had occasion to visit the Thai-Burma border, they would be able to speak to the people there. Interestingly, when I interviewed the Karen students with the same question, they agreed that it was important to learn the Karen language for their lives here as Karen-Americans; four out of six said that it was important for communicating with Karen people here. This distinction suggests that the Karen students are aware of their cross-cultural status here in the United States, while students from the dominant culture do not see themselves as participants in a cross-cultural community.

Although the Karen teacher began by instructing the students in the didactic style familiar to her from her own school history, by the end of the semester, she had shifted her instructional style to one that was more participatory. A videotape of a language lesson from the beginning of the fall semester shows the Karen teacher writing letters on the whiteboard and asking the students to repeat the pronunciation after her. The students sit in rows fanning out from the whiteboard and copy down the letters in their science notebooks. Another videotape from the end of the fall semester shows the Karen teacher surrounded by the Karen girls up at the whiteboard with the Karen boys and non-Karen boys further back in respective rows. One of the Karen girls writes Karen words on the whiteboard; another non-Karen girl draws a smiley face within one of the letters. The Karen teacher calls each of the students up to the whiteboard and helps them remember the spelling and letters of the Karen word she is teaching the group. The Karen students have essentially become co-teachers with her during the Karen language lessons. At the end of the semester, she gave a summative assessment but tailored each test for the individual student based on the level of understanding she judged they had. When the students completed the tests, she gave traditional Karen shirts to all of the non-Karen students to reward their persistence, and books to the Karen students. Although the non-Karen students sat further back from the whiteboard during these lessons than the Karen students, one non-Karen boy who usually sat doodling with his hood pulled up over his head excelled on the summative assessment. Over the course of the semester, the Karen teacher and students had called him repeatedly to come to the whiteboard for a turn; whenever they could coax him forward, they grouped around him and coached him into forming the right letters. Although neither the Karen students nor the non-Karen students

could claim expertise in this cultural knowledge, they all identified it by the end of the semester as a desirable literacy.

In the same way, the Photovoice exercises created space for the construction of cultural knowledge, and the construction of science knowledge interpreted through the lens of different cultures. Given the wide-ranging prompt of "Find things that make you think of your culture and science," students took photos of items, events and people outside the institutional boundaries of school, and then interpreted the photos to the group within the focus group discussion. Participants were asked to identify a favorite photo, a photo of a cultural item, and a photo of a science item. Karen students took photos of peppers, a shelter for livestock, squash, roselle and basil, all items they were able to find in their homes or gardens and identify as science. One Karen student, Lucy, selected a photo of a leafy green plant called roselle as her favorite photo:

Lucy:	I don't know what it's called but it's sour.
Karen teacher:	Roselle.
James:	That's my favorite vegetable.
American teacher:	And why did you pick that as your favorite photo?
Lucy:	Because it's like in our culture and we eat those and we cook with those, in soup and stuff.

Another Karen student selected a photo of the Karen flag as his favorite photo:

James:	The Karen flag.
American teacher:	Where is that flag hanging?
James:	The wall….in the living room. Karen national flag.
American teacher:	Do the colors symbolize anything?
James:	(ducking his head) I don't know what it means.
American teacher:	What does it mean to you?
James:	That's a drum.
American teacher:	Why is it important?
James:	My dad put it up there.
American teacher:	Why is it important to your dad?
James:	I don't know.
American teacher:	Why did you pick it as your favorite photo?
James:	I don't know.

Even though James was an acknowledged social leader within the Karen student social group, he was reluctant to expand on a possible political aspect of his culture within the setting of the cross-cultural learning group. This exercise took place after a presentation by a Karen community leader on the Karen flag, but before the group had begun to interact with each other socially and academically at a deeper level. At this point, Karen boys were still interacting separately from the Karen girls and the non-Karen students. Yet James could draw from his family and community funds of knowledge to conclude that the Karen flag was an important symbol for the Karen culture. Below is the narrative portrait constructed of James.

James knows things about science and culture. He came into the afterschool program as a natural leader for the Karen students; they followed his lead in most things. He has a graceful sense of humor and doesn't shout or push himself forward, but whenever a question went out to the science learning community, he had an answer ready. I think he has a quick grasp of things around him that might impact his life. He brought Pokémon into the group. When we shifted the sound wave lesson to focus more on Pokémon characters, who communicate in very interesting ways using different parts of their bodies, he carefully sketched the Pokémon lion character and endowed it with fiery breath, a deep roar that shook the earth, and a mane of flames. Embodied science for James was captured by this lion, a creature of imagination, and the paper airplane contest we held to test our question about force and motion. Paper airplanes and Pokémon, two ways of cultural knowing that gained him access to the 4th and 5th grade culture of students in this small rural school. Scoring the highest on the science quiz, James was not shy about his science knowledge. He led his small group in creating a model of the phases of the moon and explained it to the class with confidence. A measure of reserve, caution, colored his interpretation of the cultural meaning of the photos he brought in for Photovoice, though. When I asked him to explain the meaning of the photo of the Karen flag for him, for his family, or for his community, he responded, "I don't know." He brought in a photo of the Karen flag displayed proudly on the wall in his home, and offered it to the group as the cultural photo that held the most meaning for him. But when asked to explain that meaning, he said, "I don't know." Later, in our discussion

about candy in different cultures, he shared a story from his childhood in Thailand, spontaneously, without forethought. He said that his mom used to sell candy at some point when they lived in the refugee camps, and he would gather candy into his pockets at night when he was supposed to be asleep. I noticed he kept this habit: when we brought snack in for the participants in the afterschool program, James' snack went into his pockets first, to be retrieved at various intervals during the program. When asked if he thought the Karen language lessons held value, he said yes without hesitation. "Because if we don't learn our language, we might lose it forever." (Narrative Portrait, James)

Non-Karen students used their family and community funds of knowledge to identify items of cultural significance, and in at least one instance, this discussion deepened into a cross-cultural discourse. One non-Karen student, Sally, had visited Honduras several times with her family. She became our resident expert on the culture in Central America.

Tommy:	I have water, soccer, food, and…. (holds up a photo of a water fountain).
Teacher:	What is cultural about a water fountain?
Tommy:	Water is something we drink every day.
Teacher:	Why is it cultural for water to come out of a water fountain? Have you visited another country before? (to Sally) Did they have water fountains in Central America?
Sally:	No. Because that's a very poor country.
Tommy:	(holds up a photo of a soccer ball) I play every day.
Teacher:	What other countries share that culture with us?
Tommy:	Italy, Brazil, a lot of countries.
James:	Germany.
Tommy:	(holds up a photo of shelves of food at a grocery store) I took it at Dollar General. It's the place we buy food. (holds up another photo of shelves of candy)
Teacher:	(to Sally) Is candy a part of the culture in Central America?
Sally:	No.
Teacher:	(to the group) Is candy a part of the culture in Thailand?
James:	Yea, I think.
Sally:	They do have a little bit of candy.
James:	When we used to live in Thailand when I was little, my mom sells stuff and she sells candies and I like them. And at night I get up and put a bunch in my pocket.
Teacher:	Yes, I've seen that you like to put the snack in your pockets.
Lily:	(holds up a photo of a young Karen girl and looks at the Karen teacher) She's washing her clothes by hand because back in Thailand we don't have big machines to wash our clothes so we just wash them with our hands.

Lucy:	(holds up a photo of a fiber rug similar to the one we are sitting on and points to the rug) We use it like the floor; it doesn't get dirty that good and sometimes we sleep on it.
Hannah:	(holds up a photo of peppers in a big garden) Peppers. We like to grow peppers.
Sally:	In Honduras they like hot food with peppers.

Although the original design for the Photovoice focus group discussion involved minimal modification to the protocol used with the Karen parents, an adjustment became necessary when I found I had to give an explanation for *culture* with the prompt as I was handing out cameras to the students. As discussed above in the methods chapter, a key element of the focus group discussion was the game in which students identified scientific or cultural characteristics in random photos, reinforcing what we had learned about culture and science from the first part of the protocol. Tommy, in this excerpt from the first part, demonstrated an aptitude for understanding the meaning of culture:

Tommy:	(holding up a photo of a water fountain) I have water, soccer, food…
Teacher:	What is cultural about a water fountain?
Tommy:	Water is something that we drink every day.
Teacher:	Why is it cultural for water to come out of a water fountain? Have you visited another country before? (turning to Sally) Did they have water fountains in Central America?
Sally:	No. Because that's a very poor country.
Tommy:	(holds up a photo of a soccer ball) I play every day.
Teacher:	What other countries share that culture with us?
Tommy:	Italy, Brazil, a lot of countries.
James:	Germany.

Tommy also gave confident explanations when he displayed his science photos. When he held up a photo of a project on the phases of the moon that he completed for a school contest, he was able to identify the type of science it exemplified: astronomy. By contrast, Karen students were less confident in their explanations of science photos to the group. In response to the prompt for a science photo, one of the Karen students showed a

photo of a deer skeleton, but was unable to say why the skeleton was an example of his understanding of science. The same Karen student held up a science photo of ducks in a second try, but was unable to explain how it connected to science. However, during the game, when students were not singled out but could respond as a group, Karen students were more willing to attempt explanations. This excerpt from my reflective journal illustrates the higher level of engagement by students with the game:

> *Then we played a game – we split up into two teams. Lucy and Sally were captains. Students had to take turns closing their eyes and picking a photo. Then they would hold it up for the other team to see. I asked the other team to identify either a cultural or a scientific characteristic in the photo. Students were able to identify plants, animals and people as scientific characteristics. At one point, the students looked at a photo of a teenager with dyed hair and began to talk about inherited genes: genetics! They also identified several cultural characteristics such as the Karen flag, clothes that people were wearing. In one photo of Connor's room, they identified the sports trophies on the shelf as a cultural characteristic! They also focused on the Karen hot peppers as a cultural characteristic – the tendency to like spicy food.* (excerpt, October 16, 2014)

Interestingly, not only did explicit instruction and extensive scaffolding have to be built into the Photovoice exercise to elicit students' engagement, modifications had to be made to reflect the centrality of play in the out-of-school culture of the students. The students set this standard for learning early in their construction of the cross-cultural learning community, and it was upheld through various lesson plans in which we used rubber balls and paper airplanes.

Karen students and non-Karen students constructed a cross-cultural discourse using the photos they had collected for the Photovoice exercise. They accessed family and community funds of knowledge to build a framework of cultural knowledge for the learning community. Tommy exhibited insight into his own culture which could then be applied to other cultures within the spheres of knowledge held collectively by the group.

Within this context, James contributed more cultural knowledge than he had when he was sharing about his culture as an individual. In addition, he had already established his social credibility with the Karen students; here he began to gain social credibility within the cross-cultural community. Students constructed cultural knowledge together which then gave legitimacy to a cross-cultural discourse outside the mainstream discourses of the school culture. Once the focus group discussion was ended, the students played a game in which individuals identified a cultural or scientific characteristic of a photo selected randomly from the pool of photos taken by everyone in the group. The purpose of this game was to challenge each of the students to recognize cultural and scientific characteristics from different perspectives, either that of a Karen or non-Karen student. This exercise strengthened the legitimacy of the cross-cultural discourse already constructed by the group.

Implementing this structure for science learning created more opportunities for cultural and experiential funds of knowledge to shape the discourse for our learning community. Students relied upon their own knowledge or the knowledge they constructed together through interaction with each other and the environment. For example, in the lesson on sound waves as a form of energy, we used musical instruments (a guitar, a drum from Tanzania, and a xylophone from Central America) to explore how sound waves traveled; students tried to *feel* the sound waves with their bodies by placing their hands on the drums. Students experimented with the different media sound can travel through using a string and cups experiment. In addition, I used two funds of knowledge common to students in the group to explore the practical application of sound waves: Pokémon and fishing. My original lesson plan was developed around drumming

as a source of cultural and scientific knowledge. When students responded with indifference to this approach, I relied instead on their own cultural and experiential funds of knowledge. Three of the Karen boys indicated in their initial interviews that they remembered fishing as a part of their lives in Thailand. I introduced the fish character from Pokémon and asked students to speculate about whether or not the fish could communicate under water. Students were asked to design their own imaginary creatures with 3 scientific characteristics, one of which had to be a means of transmitting sound waves. This exercise allowed students to draw from their peer funds of knowledge (Pokémon was popular with Karen 4th and 5th grade boys) and their own imaginations to construct scientific knowledge together as a cross-cultural learning community.

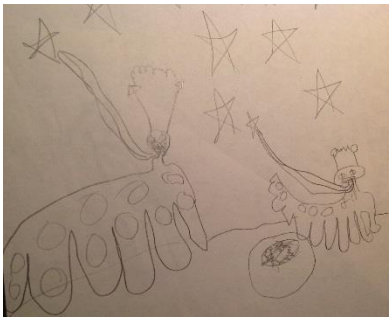


Figure9 Sally's moon creature

Sally: (holding up her drawing in her science notebook) His name is Pekondel. It was the first name that popped into my head. I don't know why. He lives on the moon and eats stars. That's why he has this extra-long tongue. He has skin and wings and legs so that he can get away. He also has electricity…

Teacher: Of course.

Sally: So he can get stars. That's also why he can eat stars. And it's also good for grabbing your prey.

Teacher: That's so cool! Eating stars! So what kind of a stomach does he have to have to digest stars?

Sally: Actually it goes up through his antennae and it gets digested with the electricity and then it goes back.

Teacher: (looking at the drawing) Ooh! And it has electricity as blood!

Sally: The poisonous skin also electrocutes.

Teacher: So that's also a defense mechanism so anyone who touches him… how does he keep from floating into space with no gravity?

Sally: You see these little dots on his legs? Those are for sticking to the moon.

Students used this exercise to construct a cross-cultural discourse in which they applied scientific knowledge to their imaginary creatures:

James: (holding up a drawing of a lion character from Pokémon) A flame lion.
Teacher: A flame lion, ok, so tell us about it.
Lily: What's his name?
James: Oh, it has thick fur so it can live in the snow.
Teacher: Oh, it lives in the snow. Ok, how does it communicate?
James: It roars.
Teacher: It roars, so it uses its throat to make a big sound. Does it have a deep or a high voice?
James: Deep.
Teacher: And does sound travel through winter air?
Students: Yes.
Teacher: Yes, of course, can't you hear something in the winter almost better than in the summer?
James: And he has long claws so he can climb on the ice.
Teacher: What's going on with that tail? Does the tail have something scientific about it?
James: Yea, electricity.
Sally: You're copying me! (Students are protesting and laughing)
Teacher: But it was such a good idea, Sally! So he does have a star on the tail so a little bit of zapper ability there?
James: (smiles at the group)
Sally: What does he eat?
James: He eats snowy rabbits.
Teacher: How does he catch the rabbits?
James: He digs up through the snow and grabs them with his saber claws. And he comes up through the ice with fire.
Teacher: He has fire coming out of his chest?
James: (points to the lion's mane, which is made of flames)
Teacher: Oh, so with his mane he can burn through the snow.

In addition to illustrating how students were beginning to construct scientific knowledge as a cross-cultural learning community, the above excerpt also demonstrates students' emerging understanding of the epistemology of science, defined here in terms of the principles of the nature of science (NOS): the need for creativity and imagination in processing scientific information; the importance of relying on empirical scientific knowledge to form new theories; and the embeddedness of science in culture, in this case, the 4th and 5th grade culture of Pokémon. Students leveraged their everyday knowledge to access more complicated scientific understanding about sound waves and then refined

this knowledge within the group. When Sally protested that her design was coopted by James, we had an opportunity to discuss how appropriate it is in science to build on each other's ideas as long as the original author is acknowledged. This discourse of imaginary creatures with scientific characteristics built on our discussion of the moon and whether or not sound waves could travel on the moon. Hannah created a zombie dog, which prompted a similar discussion of whether or not it could create sound since zombies, like the moon, did not have a medium such as air through which sound could travel. Another creature lived underwater, and we had discussed previously the idea that water could serve as a medium for sound waves. Introducing the culture of science through the exercise of proposing imaginary creatures that employ scientific characteristics allowed the learning community to move with more confidence into the scientific inquiry that followed; they began the experiment with an expectation of discovering something more about how sound travels. Rather than waiting for instructions, and looking for distractions, they began to construct the experiment themselves, using the materials provided.

Within this hybrid science learning space, students began to identify the difference between empirical knowledge based on experience and observation, and cultural knowledge. In the series of lessons on the phases of the moon, we decontextualized science knowledge about the moon by reading children's books on the cultural significance of the moon: *Under the Ramadan Moon* (2011) by Whitman and Williams; and *Thanking the Moon: Celebrating the Mid-Autumn Moon Festival* (2010) by Lin, before we created moon models based on the students' moon journals. We also asked the students to create their own moon stories, using scientific and cultural

knowledge about the moon. Our discussion that followed captured the students' efforts to understand the difference:

Teacher:	Do we have evidence that there's no air on the moon?
Students:	Yes, people have been on the moon.
Teacher:	Yes, people have been on the moon and they have measured that. You can't see that there's no air on the moon but they've been up there and they've experienced it.
Connor:	I've been on the moon.
Lily:	There are craters all over the moon.
Teacher:	(writing this on the whiteboard) How do we know there are craters on the moon?
James:	Because there are hole things.
Teacher:	How do you know there are hole things?
Chris:	Because we watched a movie.
Sally:	We see them.
Teacher:	How do we see the moon? Can we see the moon with our eyes?
Students:	Yes!
James:	There is no atmosphere.
Sally:	That means you have to be extra-heavy or extra-sticky to walk on there.
Teacher:	And what else does that mean? No stars and no predictable weather. How do the craters happen? Is there some kind of geological activity going on?
Lily:	Yes!
Teacher:	How else do we learn scientific facts about the moon? We talked about using telescopes to look at the moon.
Tommy:	Like Galileo.
Teacher:	Do we sometimes send satellites up to the moon? To collect data?
Lucy:	Yes!
Teacher:	Always the scientific is based on concrete evidence. What are some cultural things we have learned about the moon?
Sally:	Pokémon.
Teacher:	(writing this on the whiteboard) Does cultural knowledge have to be based on facts and evidence?
Students:	No!
Teacher:	What is culture about?
Sally:	It's about movies…
Teacher:	About stories, right? The Pokémon moon character lives in a moon cave. What are some other stories we have heard about the moon?
Sally:	Ramadan.
Teacher:	Yes, spiritual stories about the moon.
James:	I know a movie about the moon.

Teacher:	The one you made up about the moon, or the one about Spongebob? What else?
Lily:	One about astronauts going to the moon to discover the moon and they wore this big helmet.
Teacher:	Tell me about the stories that you've written about the moon. Are they based on fact or culture?
Lily:	Culture! And science.
Teacher:	So what are some scientific facts about the moon that you have put in your stories?
Lily:	That the moon glows very bright!
Teacher:	Does the moon glow from its own light?
Students:	No!
Teacher:	Where does the moon get its light?
Students:	From the sun! (Lily is up on her knees waving her arms in the air. She writes this on the whiteboard.)
Lucy:	And the phases of the moon.
Teacher:	What are some cultural things you have in your stories? Did some of you write about werewolves?
James:	Brad did.
Teacher:	Why are werewolves cultural and not scientific?
Sally:	Because men can't turn into wolves.
Teacher:	Is there any evidence that that can happen? Has anyone been able to document it?
Sally:	No.
Teacher:	Great discussion! Let's do a model of the phases of the moon.

Weaving a cultural discourse in to a recognized science discourse enabled Karen students to move to the center of the discussion rather than remaining at the periphery. Although students recognized that cultural knowledge was not equivalent to scientific knowledge, both were seen as important to our understanding of the moon.

Scientific Knowledge Production

Research in how elementary students understand the nature of science (NOS) has recently broadened to include an equity agenda that calls into question the legitimacy of one distinct way of knowing science. Walls, Buck, and Akerson (2013) have suggested that the conceptualization of NOS emerges not from a vacuum of objective scientific knowledge but from epistemologies that are inextricably tied to culture. However,

research on NOS in science education has been slow to articulate how culture shapes the epistemology of science, and whose culture is at the forefront of the production of scientific knowledge (Medin & Bang, 2014). For culturally and linguistically diverse students, recognizing culturally-produced knowledge within the context of science learning legitimates their ways of knowing and positions them as stakeholders in the production of scientific knowledge. Consequently, the construct of culture has become critical to learning communities that engage with community-based science curriculum. NOS has been defined as the epistemology of science, the values and beliefs associated with the production and use of scientific knowledge. Science educators have agreed on the parameters of NOS: Scientific knowledge is tentative, empirically based, subjective (theory-laden), socially and culturally embedded, and involves human imagination and creativity (Lederman & Lederman, 2012). Although the ideas of the nature of science represent the epistemology of science for many scholars in science education, in this research they did not serve as a way to measure students' advancement in science understanding. Rather, the ideas of NOS served to represent one understanding of the epistemology of science. Patterns of student engagement with the ideas of NOS thus reflected how closely aligned students' ways of knowing were with this dominant discourse in science education. Narrative analysis revealed two patterns of student engagement with the use and production of scientific knowledge as defined by NOS: 1) non-Karen students were able to access all of the ideas of NOS easily by the end of the program, whereas Karen students struggled to access NOS ideas decontextualized from the learning community; and 2) signs of emerging agency indicated that Karen students could develop and use the platform of their own epistemology to position themselves as

stakeholders in the epistemology of science. In this section, the first pattern is addressed; the second pattern is deferred to the following section.

Reflection on scientific knowledge occurred during inquiry-based lessons using the following scientific practices: building hypotheses based on observation of scientific phenomena; conducting experiments to test these hypotheses; and constructing scientific explanations based on data collected from the experiments. Below is a sample of the process used for inquiry:

Week 2 September 11

An Introduction to Physics: Potential and Kinetic Energy

20-30 minutes	I am going to show you three things. You tell me which one is the best example of the science of physics. (show the jack-in-the-box, water pouring into a bowl, a rubber ball bouncing) Show of hands. Post their arguments on the board.
	You are all right! The jack in the box is an example of a simple machine. What simple machine does this depend upon? A spring! What are some other machines that use springs? (guns, bows, clocks) This is an example of **force.** For example, a rubber band is an example of a spring. **Energy** is stored in the band when you stretch it and released when you let go. Can you explain what **force** is in action in the toy?
	The water pouring is also an example of **stored energy** being released. Does water contain **force**? What happens in a flood? If we were to pour this water down a dirt pile, would it have enough force to change the dirt, move it into a new shape? What about a dam? How is the moving water contained by a dam used to produce electricity? This is called **kinetic energy,** energy on the move.
	Another example. Here is a rubber ball. What kind of **energy** does this ball hold? **Stored energy or potential energy.** Now, when I drop it, what kind of **energy** is released? **Kinetic energy.** That is the language of science.

Constructing a scientific explanation

	Let's build an experiment. Here is our question: Can a small ball bounce higher if it bounces off a larger ball? So, for example, here is the large ball bouncing. You are going to measure that. Then here is the small ball bouncing. Measure that. And now bounce them both together, the small one on top. Measure how high the small ball bounces (using the meter stick, mark off one meter on the wall). Does the small ball bounce higher? Why or why not? Record measurements on the board. (transfer of energy from the larger ball to the small ball). What **claim** can we make based on this experiment? What **evidence** do we have to support this claim? Are there other arguments we can make based on our evidence?
Reflection	How can we define **stored energy (potential energy) and kinetic energy** using our experiment with the balls?

The toys and pouring water were used to situate science inquiry within students' experiential knowledge, although it could be argued that Karen students may or may not have been familiar with a jack-in-the-box. Students came to associate kinetic and potential energy with these concrete examples. For weeks after we had completed the lesson on kinetic energy, I brought the jack-in-the-box back to the classroom and laid it out on a table for students to handle during their free time. When I tested the students in a written assessment, I asked for examples of kinetic and potential energy. Similarly, in the experiment we performed with bouncing balls, when we examined the data, we realized students had used two different sides of the meter stick to measure the height. The data was recorded in both centimeters and inches. Since our previous lesson had been on the importance of accurate measurement in science, the students were able to recognize that the data was not as accurate as it could be, and they decided to re-do the experiment, using centimeters as a consistent unit of measurement so that the data would be more accurate. This process of recognizing the importance of reliable data for

constructing scientific explanations based on evidence provided an easy segue into a reflection on the empirically-based nature of science: how a change in units of measurement could alter the data and any subsequent explanations.

Similarly, science lesson plans were more engaging for students if they were embedded in contextually authentic science inquiry that reflected the students' culture in explicit ways. In the class time on October 2, we looked at Galileo's inventions and talked about his culture at the time of his inventions. One student, Tommy, had expressed an interest in learning more about Italy (he chose Italy as his site for the natural history project); his interest stemmed from a passion for Ferraris. The other students were relatively disengaged from learning about Galileo's culture. The following excerpt from my reflective journal illustrates the epiphany moment I had reflecting on class time from October 2, in which students also showed little interest in a video on sound waves and an African-American elementary student playing the drums:

> *My epiphany is this: rather than looking at science and culture in **general** (for example, looking at Galileo's culture at the time he discovered Jupiter's moons), I am going to focus more on **their** culture. For example, a lot of the boys have said they like fishing and Pokémon. So I am going to focus the next lesson on sound waves underwater and on the moon (per Sally's scientific inquiry about growing plants on the moon). I would also like to look at Pokémon creatures to see if there is one that has sonar powers.*

The modified lesson plan for October 9 reflected these changes:

> **Review: Sound waves are a form of energy.**
>
> Last week we looked at sound waves and the **frequency.** Who remembers how the frequency affects the sound of waves? (higher frequency, higher sound) Where do waves come from? (disturbance in air, water, etc)
>
> **Scientific Inquiry**
>
> Now that we have an idea of what sound waves look like, can we speculate about what **medium** sound waves travel through to get to us? Let's consider two scientific questions:
> **Can sound waves travel on the moon?**

Can sound waves travel under water?
Show ppt with Pokémon character. Ask the students to draw a character that can emit sound waves either on the moon or under water. Each character should have 3 scientific characteristics that the students can explain to the class, 1 of which needs to be about sound (examples: particular kind of skin that absorbs sound; sound transmitted through touch or eye contact, etc.). Students can make these drawings in their scientific notebooks or on construction paper.

Gather the class to discuss their drawings in the large group after 10 minutes or so.

Experiment on sound waves

Materials: hangers, string, plastic cups

Cut different lengths of string for each group (2-3) of students. Attach one end of the string in the end of the cup and the other end on the hanger. One person holds the cup to their ear while the other person plucks the string.
Experiment with the sounds when the strings are plucked. Which sound is higher? When the string is short or long? Write your observations in your science notebook.

Reflection

What have we learned about sound waves (that shorter strings have more tension and the waves are higher) Can we relate this to the strings of a guitar? Which strings make a higher sound? What about the drums? This comes from **frequency.** Draw different waves on the board.

This lesson plan embedded science inquiry within the students' culture of play: Pokémon. By using an explicit cultural approach to scientific inquiry, I found that students were able to use their imaginations and their cultural knowledge to access greater understanding of science concepts. Below is the section of the NOS chart for this 2-week lesson on sound waves that equates NOS ideas with scientific inquiry and cultural knowledge:

10/2/2014 – 10/9/2014	Physics: Sound Waves	Scientific knowledge is culturally embedded; imaginative and creative; empirically based	Sound traveling through musical instruments; slinky demonstration of amplitude; experiment with hangers and cups	PS4.1 Wave model	Historical look at Galileo, his culture and how his culture might have affected his scientific discoveries; study on the cultural significance of music: why are cultural traditions important? Invention of creatures that can transmit sound waves

This lesson exemplified explicit teaching on NOS ideas: that the production of scientific knowledge emerges in part from our cultural understanding of the world; that students have to use their imaginations to construct scientific theories about the nature of things that we might not know about yet; and that scientific claims are based on evidence gathered from data. It also exemplified explicit teaching on culture: students were able to create creatures based on their cultural understanding of Pokémon. Similarly, in the inquiry lessons on the moon, explicit instruction on the science and the culture of the moon was embedded in the lesson plan:

Week 8 October 23 Earth and Space: Phases of the Moon
http://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.mphase/phases-of-the-moon/

Sharing myths about the moon

Share a couple of books written about the moon that tie in to children's cultural beliefs. Why is it important to honor our cultural beliefs? Why do so many people associate the moon with spirituality? What is the relationship between spirituality and science? Can we respect both at the same time? Even though we know most stories about the moon are not scientifically true, why are they important anyway?

Illustration

Rona, Maori legend of the moon
http://www.youtube.com/watch?v=2z5YhELaILk

Aboriginal legend of the moon
http://www.youtube.com/watch?v=C9BBZz9qSvE

African legend of the moon
http://www.youtube.com/watch?v=UWU2oyqCg5o

Writing stories about the moon

In the blank books provided, design and illustrate your own story about the moon, using your own cultural knowledge about your people, your family, and what they believe. If you don't know a cultural story about the moon, you can make one up as long as it illustrates something important about your culture.

Week 9 November 6 Earth and Space: Phases of the Moon

Sgaw-Karen lesson

Phases of the Moon Project

We have looked at scientific and cultural knowledge about the moon.
What are some scientific facts we know about the moon? (no air so no sound; no atmosphere so the sky always appears black; very little gravity)
Why does the moon appear in phases on different nights?
What have you observed from your moon journals?

What is the difference between scientific knowledge and cultural knowledge? Does cultural knowledge have to be supported by evidence?
What do we know about how people have collected cultural knowledge that is centered around the moon? Spiritual meaning, cultural meaning of the moon. Read Rabbit and the Moon Man, a Cree story about the moon.
In the stories you have written, what are some of the cultural characteristics that you included? Any science facts?

Phases of the Moon Model

Materials needed for each team: 8 small Styrofoam balls, 1 med Styrofoam ball, 1 large Styrofoam ball, toothpicks, flat surface for base, flashlight, black marker

1. Stick a toothpick in the large Styrofoam ball and stick the other end of the toothpick in the base near one edge. This ball represents the sun.
2. Do the same for the medium ball and place it in the center of the base. This ball represents the Earth.

3. Using the marker, color exactly half of each of the small balls black. These will represent the different phases of the moon.
4. Draw a diagram on a piece of paper that shows the position of the Moon, Sun, and Earth during each of the following phases of the moon:
   New, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, waning crescent
   Have all of these phases illustrated on a chart for children to refer to.

5. Create a 3-D model of your diagram by using toothpicks to attach the Styrofoam moon balls to the base in their proper positions relative to the Earth and Sun. Imagine you were standing on the Earth ball and position all of the moon balls accordingly.
6. Darken the room and hold a flashlight next to your Sun to test your model. Move the balls as necessary so they are in the correct positions relative to the Earth and Sun. Label each phase on the base.

Reflection

What does our model tell us about the phases of the moon? Why does the moon appear in different stages of light and darkness at different times of the month? (because we are viewing the reflection of the light from the sun off the moon from our perspective on earth)

Time for work on the moon stories

Hubble Telescope Movie (5min)

In the group discussion about the moon cited above, students were able to identify scientific facts about the moon based on evidence, and distinguish between those scientific characteristics and cultural characteristics such as the spiritual meaning that some cultures give to the moon. Below is the section of the NOS chart illustrating the congruence of NOS ideas with science inquiry about the moon and cultural understandings about the moon:

10/23-11/6	Earth and Space: Phases of the Moon	Scientific knowledge is culturally embedded; imaginative and creative; empirically based; subject to change	Moon journals; Model of the phases of the moon	Constructing models; S5CS6. Students will question scientific claims and arguments effectively.	Children's literature on cultural beliefs about the moon; why are cultural beliefs important and how are they different from scientific knowledge about the moon? Students write their own stories about the moon, and illustrate them.

In this lesson, students were able to explore both a scientific understanding of the moon based on theories supported by evidence, and an imaginative cultural understanding of the moon based on spiritual and mythological stories about the moon. Explicit instruction and reflection on both were structured into the lesson plan.

Using this model of explicit-reflective instruction for both culture and NOS ideas throughout the remaining lesson plans, I conducted an informal assessment of the conceptualization of NOS ideas that Karen and non-Karen participants were able to gain by the end of the four-month program. Based primarily on the closing interview, Karen students did not exhibit an ability to step into the identity of scientists as readily as the non-Karen students did. For example, in response to the question, *Do you believe that what we know about science changes over time? For example, can our scientific knowledge about the moon change? What would cause it to change?* only the non-Karen students spoke with any confidence about what might cause that change. The belief that scientific knowledge could change over time is one of the ideas that NOS attempts to convey: science knowledge is tentative. The following is an excerpt from Sally's closing interview:

Teacher:	Do you believe that what we know about science changes over time? For example, can our scientific knowledge about the moon change? What would cause it to change?
Sally:	Sure! Global warming.
Teacher:	What about our knowledge about the moon?
Sally:	Yea, we could go out of orbit; the sun could explode.
Teacher:	What happens to make people change their mind about science?
Sally:	They gotta be persuaded.

Sally agreed without prompting that science changes over time, and referred to global warming as an example; Tommy agreed emphatically as well, and cited the continuous invention of new things as an example. When asked what might cause our understanding of the moon to change, Sally said again without prompting, that the moon could go out of orbit or the sun could explode. By contrast, Karen students struggled to verbalize how science could change or how they could make a scientific discovery. In the interview with Lucy, for example, she responded, "Sometimes science can change; science and culture can be like the same sometimes," in response to the question of whether science could change over time. However, when asked if it was possible to learn about science at home, Lucy cited three examples with confidence, "Planting in the garden, see each day if it grows at all; when you're like cooking; to see when things are rotten." All of the Karen students were able to cite three examples, such as gardening, studying the moon, and cooking. Based on this and participant observation in the learning community over several months, I inferred that Karen students occupied a peripheral position in the science culture, as defined by NOS principles. Although we were able to create space for science learning in which cultural knowledge gave Karen students a way to "belong" to the learning community, and students were able to construct science knowledge within that space, the discourse and disposition of science culture as defined by the dominant culture remained in large part inaccessible. However, signs of emerging agency indicated

that Karen students could access rigorous scientific practices and produce scientific knowledge using their own ways of knowing within the cross-cultural learning community.

Evidence of Emerging Agency

In the narrative analysis of phase two of this research, I used agency as an indicator of how students positioned themselves in relation to engagement with science inquiry. In critical pedagogy, Freire (1970) described the relationship of educators to students as dialogic, set within a climate of reciprocity. Within this setting, students could generate their own discourses based on critical reflection of the world around them without fear of sanction (p. 109). Therefore, agency in science learning served as an indicator of the confidence with which students could produce their own knowledge and access rigorous problem-solving scientific practices. Mainstream and non-mainstream cultural and scientific knowledge discourses were available within the cross-cultural learning community. Adopting various discourses throughout the four-month program, student participants moved in and out of various individual science learning identities and group social identities. In general, their interaction with each other and with the teachers created an overall community learning identity that legitimated their individual identities in some instances and challenged the assumptions made by mainstream discourses in other instances.

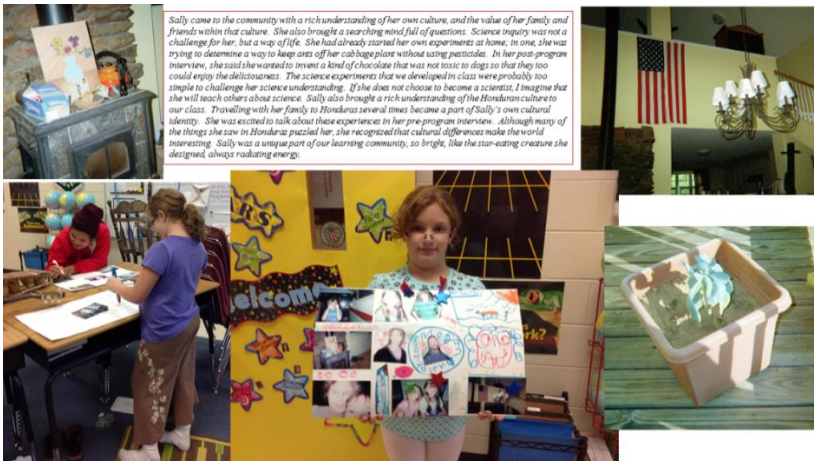
Academically, decolonization of the science learning space occurred through the inquiry framework of constructing scientific explanations, and shaping and challenging evidence-based arguments that supported or refuted these explanations. Framing all of the science inquiry projects within the scientific practice of constructing scientific

explanations based on evidence created space for student participants to exercise agency. In this cross-cultural learning community, some of the students demonstrated a predisposition for engaging in agency in science learning. Since this afterschool program, called Science and Culture, was offered to non-Karen students already participating in a structured afterschool program offered by the school, it is not surprising that those who chose it were interested in science. Sally, a non-Karen student, showed a predisposition for science inquiry early in the program. In the Photovoice exercise, she selected a science photo of an experiment she was currently engaged in:

Sally:	I have 2 science pictures. This is my cabbage and I'm trying to find a way for the ants to stop from getting it.
Teacher:	Is this a science experiment that you are doing?
Sally:	Uh huh.
Teacher:	What is the question you are trying to answer?
Sally:	What will make the ants stop? What will not harm the plant but hurt the ants?
Teacher:	That's a great science question. So what have you discovered so far?
Sally:	(laughs) Nothing.
Teacher:	Did you try something?
Sally:	No.
Teacher:	What are you going to try?
Sally:	I don't know. (holds up a photo of a ball) And this is stored energy, the end. It's a ball. When you kick it, it moves.

Sally's confidence in her role as an agent in science learning was apparent also in the closing interview cited above. At several points in this interview, Sally demonstrated exceptional insight with regard to science learning; this was particularly evident in the statement that people needed to be persuaded in order to come to a new understanding in science. By contrast, her insights into cultural knowledge seemed to be limited to her own culture. Although the purpose of cultivating a cross-cultural learning community was ultimately to create a more equitable learning platform for Karen students, non-

Karen students who participated in the program demonstrated a more complex understanding of their own culture by the end of the program. This was appropriate since all of the participants were asked to explore the meaning of science within their own home culture, using family and community funds of knowledge, during the Photovoice exercises. However, one benefit of participating in a cross-cultural learning community could be to challenge assumptions and discourses about other cultures present in the dominant school culture. Below is Sally's narrative portrait:



Sally came to the community with a rich understanding of her own culture, and the value of her family and friends within that culture. She also brought a searching mind full of questions. Science inquiry was not a challenge for her, but a way of life. She had already started her own experiments at home; in one, she was trying to determine a way to keep ants off her cabbage plant without using pesticides. In her post-program interview, she said she wanted to invent a kind of chocolate that was not toxic to dogs so that they too could enjoy the deliciousness. The science experiments that we developed in class were probably too simple to challenge her science understanding. If she does not choose to become a scientist, I imagine that she will teach others about science. Sally also brought a rich understanding of the Honduran culture to our class. Travelling with her family to Honduras several times became a part of Sally's own cultural identity. She was excited to talk about these experiences in her pre-program interview. Although many of the things she saw in Honduras puzzled her, she recognized that cultural differences make the world interesting. Sally was a unique part of our learning community, so bright, like the star-eating creature she designed, always radiating energy. (Narrative Portrait, Sally)

After two months of meeting once a week, Karen students began to demonstrate agency in constructing scientific and cultural knowledge for the community. Evidence of two instances of agency in constructing scientific knowledge and one instance of agency

in constructing cultural knowledge is given here. The first took place during the construction of models of the phases of the moon. In response to a moon journaling project in which students were asked to view the moon every night for a month and record data such as the time, weather, and shape of the moon, Lily was able to make several observations and share them with the class. Based on her observations over several evenings, the group attempted to construct models of the phases of the moon. Connor, demonstrating expert knowledge gained from a previous class project, had brought in a model made at home to show the group. For the project, I handed out illustrations of the different phases of the moon so that they could become more familiar with the names of the different phases, and all of the materials they would need to construct the models. A completed model was not shown at this time, and students were not given explicit instructions on how to create their models. Rather, the expectation was that they would use the knowledge they had constructed through the moon journaling project and interacting with each other around this project to build their own models. Students were divided into small groups, two of which had Karen and non-Karen participants. This structure did not happen naturally but was imposed by the teachers to encourage cross-cultural collaboration.

The small group composed entirely of three Karen boys relied on the leadership of James, who had demonstrated academic ability previously in the group. The small group of two Karen girls and one non-Karen girl developed tension from the start. One of the Karen girls, Lucy, had demonstrated academic leadership within the group of Karen girls participating in the learning community. However, the one non-Karen girl, Sally, who struggled to fit socially into a sub-group within the learning community with

limited success, also had an expectation of academic leadership. I was videotaping students' presentations of moon models in the following excerpt:

Teacher: (to Tommy, Connor and Lily)
Can you explain your model?

Lily points out the different phases of the moon represented in the model.

Teacher: Does anyone have questions about this model?

James checks his diagram and points to one of the Styrofoam balls:

James: That looks like a gibbous moon.

James explains his model. He has the class stand by the ball representing the sun so that we have the correct perspective. Then he names all of the phases of the moon.

Teacher: Does everyone agree with this model? Does anyone have questions?

Lily checks the model carefully and questions a couple of the positions, which James explains with no hesitation.

James: Yea, nothing's wrong.

Lucy and Sally are arguing over the positions of the balls on their model.

Teacher: Lucy, why don't you explain your proposed model to us first and then Sally can present the model in a different way.

Lucy arranges the balls representing the moon phases according to the diagram.

Sally (hands on hips): Would the shadows really be facing the sun?

Teacher: Lucy, where do you need us to stand in order to get a good perspective? Sally, back up just a bit.

Lucy names each of the phases.

Teacher: Now, Sally, you can rearrange the moons.

Sally: Can you put the camera on top of the earth? Right above the earth? If you were standing on the earth, if you look over here, it's a full moon, and over here, a gibbous moon.

Sally faces all of the white sides of the balls toward the ball representing the sun.

Sally: If you're on the earth looking around, it would all look different, even though all of the balls look the same right now.

Chris: I agree with Lucy's model.

Although Lucy was normally quiet and reluctant to call attention to herself, she was adamant that her interpretation of the phases of the moon model was correct. Sally was equally as adamant. Both students were asked to construct their models for the group, and explain their reasoning behind the model. The group could challenge the reasoning behind either model, which they did. Holding the scientific practice of modeling as the learning objective allowed the Karen student to become an agent of constructing scientific knowledge for the group. Although she appeared anxious that her model was wrong, she presented her model and her reasoning with determination, giving credibility to her role as an academic leader within the learning community.

A second instance of a Karen student taking agency in constructing scientific knowledge for the group occurred in a project in which the students worked in small groups to design aquifer models. Students were divided into small groups and given four different types of soil: clay, topsoil, gravel and sand, to simulate the layers of the earth. They were asked to choose the layers that would allow for the most absorption of water, to simulate an aquifer. Once they had layered the soil types in two liter bottles, the models were tested by creating "wells" in the middle and measuring how much water accumulated in the well. One Karen boy, Brad, who had not demonstrated academic leadership in the group thus far, primarily because he participated in Fit Club every Thursday and missed most of the science lessons, relied upon his family funds of knowledge to make a claim about which layers should go where in the aquifer project.

The two non-Karen boys in his small group disagreed, and all parties were asked to present their arguments for the group. Although this interaction was not captured on video, the following is an excerpt from my reflective journal entry for that day:

> *When Connor came in in the middle of the weather lesson, he immediately acted out: went to the classroom doorway and began doing jumping jacks while I was speaking. So interesting! It must be a way for him to break into the cozy social group we have already set up for the afternoon. Although Tommy is always so happy to see Connor – you would think that would be enough of an "in" for him. Today was the last day of "Fit Club" so he will be with us from the beginning next time. It will be interesting to see how he behaves. The experiment went well – my organizational details were not on the mark but everyone adjusted well. PSP, me and Lucy were randomly chosen as group leaders, although Connor, Brad and James all step naturally into leader roles (and Lucy of the girls has the most confidence with experiments). Connor and Brad ended up in PSP's group with Tommy and disagreed on which layer – gravel or sand – to put in the bottom of their aquifer. I allowed them to provide arguments and in the end Connor yielded to Brad's judgement. Brad, a gifted artist, drew the model for PSP's group. Lily drew the model for her group. All of the groups struggled with the part where the nylon stays in the hole. In the end, no one was able to produce any water from the "well" but it was cool to watch the water filter down through the layers. A very successful experiment – and one we can come back to when we are planning the garden.* (excerpt, Teacher's Journal, January 8, 2015)

Although Brad had not claimed expertise in the learning community on previous occasions, he was adamant in this case, and eventually his argument prevailed over that of the non-Karen boys. When the aquifer model was constructed by the group according to his specifications, he assumed the responsibility for drawing the small group's model in his science notebook, and he recorded the amount of water they applied to the model and measured the amount of water they were able to recover from the "well" in the middle. When all of the models were completed, he shared the results of his small group's experiment with the large group. In this way, he assumed agency in the construction of science knowledge for the learning community.

In an example of how Karen students began to demonstrate agency in the construction of cultural knowledge, one Karen student, Lily, positioned herself as an agent of expert knowledge in the Karen language lessons. As indicated earlier, the Karen co-teacher transitioned from a didactic method of instruction at the beginning of the program to a more interactive method by the end of the program. Lily similarly moved from a position seated at the front of the semi-circle of girl Karen and non-Karen students to a position next to the co-teacher at the whiteboard. By the end of the program, Lily was writing the words on the whiteboard for the Karen teacher and reciting the correct answers if other students struggled to respond. She positioned herself next to the teacher with the marker in her hand poised to teach the Karen language lesson. None of the other students positioned themselves in this way. In her closing interview, Lily's response to the question about which cultural activities in the program she liked the most, including Photovoice and the guest speakers, she identified the Karen language lessons:

> Lily: Well, you see, when I came to Minnesota and then here, I speak a lot of English and I don't really know Karen that much. So I like it because I get to learn my language again and I can speak to Karen people and just talk to them.

Although Lily did not gain as much confidence in the science culture, she did move into a leadership position within the group that allowed her to position herself as a science learner with higher academic capital. When she participated in the moon modeling project in a small group with two non-Karen boys, she did not retire quietly to the periphery but rather inserted her own opinions about how the model should be constructed. When the teacher asked if everyone agreed with the models the three groups had constructed, Lily took the time to inspect each model before she agreed. This seemed to indicate that she was leveraging her knowledge of the Karen language to

position herself within the science culture as a science learner on equal footing with the non-Karen students. Lily challenged the mainstream assumption that placed her in a culturally deficit space by positioning herself as someone with the social and academic capital to act as an agent in learning. Below is Lily's narrative portrait:

Lily brought a positive energy to the learning community that all of the participants appreciated. Upbeat and witty, she kept the community laughing. When she presented her imaginary creature, Blueberry, to the class, we all saw a drawing of a boy on the ground in front of Blueberry. Jack was a boy that Blueberry wanted to eat, Lily said. Jack was the owner of Blueberry. She pretended to be nice and beautiful and other stuff, but when it's time to get hungry, Lily said, she will eat this boy. Blueberry is bright blue with a giant eye in the middle of her amorphous head. She smiles a toothy grin. Lily is an excellent artist; her drawings of the Pacific Ocean for the natural history project are full of cheerful starfish and fish. Did she want to include an underwater volcano? I ask. No, she said, thanks anyway. Lily is not afraid to challenge the other students with her quick wit and attention to the task at hand. In the Karen language lessons, she is a star, and sits closest to PSP, the teacher. By the end of the program, she has the dry eraser in her hand and sketches the Karen letters and words on the board from memory. The Karen language lessons were her favorite cultural topic out of everything we did in the afterschool program. "Well, you see," she said in her closing interview, "When I came to Minnesota and then here, I speak a lot of English and I didn't know much Karen. So I like it because I get to learn my language again and I can speak to Karen people and just talk to them." (Narrative Portrait, Lily)

Learning to articulate characteristics of their culture and apply this knowledge to science learning required explicit instruction. Although the cultural and science learning identity of the community took shape directly from the Photovoice exercise, through learning about differences and similarities in the students' home lives, this was more an exercise in interruption of identity formation than in continuity for the Karen students.

Karen participants in the program seemed to be more focused on blending in to the culture of the school than on retaining characteristics of the Karen culture. For example, in the activity in which students created an imaginary creature that could emit sound waves, James was more comfortable copying a Pokémon creature than creating one of his own, and Chris copied the creature James copied from the internet. By contrast, Tommy, a non-Karen student, created a creature in the shape of the country of Italy to reflect his interest in Italian sports cars. For a community such as the Karen, with families mostly absent from the school other than the required parent-teacher conferences, it was not surprising that Karen students would be heavily influenced by the school culture and tend toward total assimilation rather than the cultural blending of acculturation. However, the learning identity of the community reflected this tension. In general, the identity of the group was dominated by the American culture present in the classroom despite our efforts to decolonize the space. Karen students had become adept at imitating this culture in order to blend in, intuitively, in the same way that Karen adults had cultivated a narrative of invisibility in the larger American community and a counter-narrative to push back against assimilation into the dominant culture of Burma and Thailand.

Karen and non-Karen students began to identify meaning contained within their own culture during the first Photovoice exercise and leveraged this knowledge to access a deeper understanding of how culture could influence science knowledge. In this research project, decolonization took place physically through the restructuring of the space of the classroom and through intentional power re-distribution through the cross-cultural learning community. As discussed earlier, we met on the floor in a circle using a woven mat that many Karen families used in their homes. Re-inhabitation occurred in small

ways when the students populated the space with their family and community narratives through Photovoice, and then constructed embodied science knowledge based on their experiential knowledge. Science inquiry projects on the moon and sound waves in particular solicited cultural knowledge from student participants. For the moon project, students read children's books on cultural traditions centered on the moon and wrote their own stories on the moon, using cultural and scientific knowledge. Afterward, we had a group discussion about the moon in which we distinguished between cultural and scientific knowledge. In the discussion about the sound waves inquiry project, I cited evidence of the students using their imaginations to create scientific creatures that could transmit sound. Students pulled from their imagination and cultural knowledge to design their own characters, one of which had electricity for blood and ate stars. Although not technically standards-based science inquiry, their designs did raise inquiry questions and lead to interesting discussion about sound waves that integrated the science we had learned earlier. Evidence from closing interviews indicated that most of the students were able to distinguish between cultural and scientific knowledge.

Conclusion

Patterns of emerging agency on behalf of the Karen students indicated the presence of a hybrid learning space within which students could leverage their cultural knowledge and position themselves with more confidence as science learners. Karen students leveraged their expert knowledge from the Karen language lessons to advance in agency in science inquiry. They engaged in argumentation, decision-making, and even leadership roles in several instances. Karen and non-Karen students were able to learn more about the meaning of their culture and apply this knowledge to inquiry lessons such

as sound waves and the moon modeling project through cross-disciplinary exercises such as creating imaginary creatures or writing stories about the moon. Non-Karen students were able to position themselves with confidence as science learners and achieved some conceptualization of NOS. Their closing interviews also gave evidence of a stronger more cohesive understanding of cultural knowledge than was apparent in the pre-program interviews. Finally, Karen students did not engage with the ideas of NOS as easily as non-Karen students did, which could indicate a disparity between their ways of knowing and the epistemology of science as defined by the dominant culture.

The following chapter examines how this process of making culture legible through the creation of a cross-cultural learning community made scientific practices accessible and increased cultural resilience for Karen students. Although a cultural counter-narrative was not apparent among the Karen students as it was among Karen parents, Karen students moved with caution and care into positions of agency in the learning community. Two of the six Karen students did not move at all into positions of leadership or decision-making in the construction of scientific or cultural knowledge within the community. At the end of four months, they remained at the periphery of the group in knowledge construction and agency. Even those students who did share details about their family life did so hesitantly within the group; for example, James responded to questions about the importance of the Karen flag to his family with "I don't know," which could be interpreted as a reluctance to share too much cultural knowledge with non-Karen students present. In addition, when the Karen pastor came to the afterschool program to share his knowledge of the Karen national flag, Karen student behavior reflected a level of discomfort with his presence in the learning community. This could

be an indication that Karen students viewed the embodied knowledge he represented as displaced. Although his knowledge was highly regarded in the Karen community, and was central to the counter-narrative of the parents, Karen students did not seem to regard his knowledge as central to their own science learning or cultural narratives. This seems to indicate that a certain fragility characterizes the resilience of first-generation refugee children.

Figure 12 Karen pastor visits the afterschool program to teach on the Karen national flag.

CHAPTER 5

Decolonization and Re-inhabitation of a Science Learning Space through a Cross-Cultural Learning Community

The purpose of this research study was two-fold: 1) to allow Karen parents in a small rural community to represent their own culture in a public forum by identifying what cultural knowledge they would like their children to retain as they transition into the U.S. educational system; and 2) to explore how that knowledge could be leveraged within a cross-cultural learning community for 4th and 5th grade students to advance Karen students in science learning. To facilitate this research, I partnered with Karen parents to design curriculum for and teach in an afterschool science and culture program at a local elementary school in which Karen students and parents were a minority population. In Phase One, I worked with Karen parents to explore the key characteristics of cultural and scientific knowledge they identified as essential to the sustainability of their culture in resettlement. The following questions guided this part of the study: What key aspects of their culture do Karen parents identify as critical to the healthy development of their children's cultural identity as Karen Americans? For Phase Two, I co-taught Karen and non-Karen students with a Karen parent in a science afterschool program outlined above. The following questions guided this portion of the study: 1) How does the construction of a cross-cultural learning community that privileges Karen cultural knowledge affect the science learning of Karen student participants? And 2) How does the presence of Karen cultural knowledge represented by a Karen co-teacher and the Karen language affect how students position themselves within the learning community?

In this research, I explored how building a cross-cultural science learning community might impact how Karen elementary students engage with rigorous scientific practices and participate in constructing scientific knowledge. Scientific practices such as constructing explanations based on evidence required an advanced level of linguistic and cultural understanding that were challenging learning objectives for first-generation refugee students, given the cultural and social obstacles they had to navigate in long-term displacement and resettlement with their families. Research on integrating culturally diverse elementary students into the epistemology of science has yielded limited insight into how students can use their own ways of knowing and learning in the science classroom. Often the teacher is responsible for accessing the students' family funds of knowledge and integrating it into the classroom culture; however, since the majority of teachers in this country view non-dominant cultures through the lens of the dominant culture, the process of integrating diverse cultural knowledge into the classroom can be problematic.

Although critical scholarship on the nature of scientific knowledge and the integration of multiple epistemologies into the science classroom provided an essential foundation for this project, working collaboratively with parents and students in a local Karen community yielded valuable insight into the process of rebuilding cultural resilience that a first-generation political refugee community might encounter in resettlement. The story of how Karen parents and students constructed scientific knowledge and shaped science learning identities within a heterogeneity of Karen-American cultural knowledge is nested within this metanarrative of resilience. For a people who cultivated silence and invisibility for their own survival in Burma and

Thailand, the process of articulating keystone characteristics of their culture and legitimizing their knowledge by incorporating it into the plans for an afterschool program in their host country could potentially endow their knowledge domains with the power to transform participants and their families into actors re-constructing their own hybrid culture.

The results of this research indicated that for this Karen community re-creating their political and cultural voice in order to represent themselves in a critical arena such as education could not fail to impact the identity trajectory of Karen students in science learning. How students saw themselves through the eyes of teachers and students within the dominant school culture and within the culture of the science classroom, as cultural "other" or as legitimate participants in the use and production of scientific knowledge, could depend in large part upon the validation of students' existing cultural and experiential knowledge in the science classroom. Therefore, my research relied upon the critical perspective of place-based pedagogy, rooted in the critical pedagogy of Freire, to create a cross-cultural learning community within which we could interrogate relations of power in an elementary science classroom and allow students to populate their own learning space with meaning.

The conceptual framework of social-cultural resilience allowed me to view this community's knowledge as a confluence of cultural, social and scientific streams that enabled these parents to re-build resources for renewal and adaptation in resettlement. This research called into question the political viability of dis-embodying their knowledge by separating it from their individual and collective narratives and subjecting it to Western interpretation and categorization. It was important to try to avoid the

pathogen of reducing their knowledge to forms that would make them legible for the dominant culture, allowing for greater assimilation and reification of their unique cultural and scientific literacies. Therefore, the creation of a hybrid space within which Karen parents could construct their own cultural identities through visual narratives and story-telling was essential to this research.

In this chapter, I discuss first how this action research with Karen parents and students contributes to the literature in science education, and touch briefly on the implications of phase one for the afterschool program with Karen elementary students. The findings from phase one informed the design of phase two methodologically and theoretically, and continued to inform how I interpreted the findings from phase two. Since research with Karen students and parents is at the time of this writing absent from this body of literature, the contribution of this research might be significant. Second, I situate my research findings from phase two within the larger body of literature on science education with culturally diverse students and discuss ways future research could advance our understanding in this field. For example, how could explicit instruction on culture framed within a cross-cultural learning community impact science teaching and learning within the mainstream science classroom? How could shifting to a community-based dialogic pedagogical approach in the mainstream classroom impact the science learning identities of culturally diverse elementary students? How would this look after three years? After five years? Is this approach sustainable? And finally, by using the lens of critical place-based pedagogy, I hope to contribute to the discussion of how the construction of cultural counter-narratives in science education has expanded the terrain of the production and use of legitimate cultural and scientific knowledge.

Phase One: Conserving a Confluence of Knowledge Streams

Karen parents demonstrated through their narratives how pivotal the memory of their experiences in Burma and Thailand has become to their collective identity in resettlement; yet their social and cultural narratives may change as they adapt to this new environment and look for alternative ways to manage and redistribute their funds of knowledge. Although they have been displaced from Karen State in Burma, their memories seemed to linger there, and continued to inform how they shaped a relationship with the land in rural southeast United States. Placing their self-sustaining embodied knowledge within the context of place-based pedagogy recognized the primacy of this relationship to rebuilding community resilience. As demonstrated above, the community garden functioned not just as a garden but as a community center, where Karen families gathered for meals and social interaction every weekend. The knowledge shared at the community garden connected them to a rich history of their culture apart from the violence of military attacks and internment. It was a storied landscape that contained layered meaning for the Karen community. Like the Karen Christian Church, it linked them to the lifestyle they remembered in Burma, the self-sustaining lifestyle of their parents and their grandparents. The act of cultivating food and caring for livestock anchors these parents in the past and present as agents of self-determination. Karen knowledge of horticulture and animal husbandry would be the most likely science knowledge that could anchor their children in the cultural heritage of the parents within the context of a cross-cultural learning community. In the same way that Hammond (2001) used the Mien knowledge of house-building to construct a science learning space in which multiple cultural voices could be heard, the design and cultivation of a school

garden using seeds for purple beans, bitter melon and Roselle, could serve as a representation of Karen embodied knowledge within the institutional school setting. In this hybrid space constructed outside of Western knowledge and organizational boundaries, a reciprocity of knowledge embodied in the lives of parents could be cultivated.

Of the six processes (focusing on what matters to the people affected; describing what matters in meaningful ways; making a place for these concerns in decision-making; evaluating future gains and losses from a historical baseline; recognizing culturally derived values as relevant; and creating better alternatives for decision-making so that invisible losses will be diminished or eliminated in the future) Turner and colleagues (2008) recommended for the rebuilding of cultural resilience, the opportunity for self-determination through working the land seemed to address several. By identifying farming as a rich cultural resource that links their past and present, this project focused on parents' knowledge in a way that accentuated their potential for shaping their future and the future of their children rather than accentuating their loss. Articulating their knowledge of working the land situated these parents as co-designers of the afterschool science program rather than as passive volunteers resigned to the periphery. In addition, identifying parents' interest in education satisfied two of the processes for rebuilding cultural resilience. By creating space for their concerns in decision-making at the institutional school level with regard to a potential afterschool science program, this research project created space for better alternatives for decision-making in the future. Karen adults identified educational opportunities for themselves (in learning English and getting their citizenship) and for their children as being transformative. In the case of one

young Karen woman who graduated from the local high school and was beginning to navigate the admission process of the local community college, careers that required higher education such as nursing and teaching that were not a possibility for her parents or grandparents became accessible for her.

The cultural knowledge identified through these visual and written narratives revealed sentinels of the Karen cultural heritage that sustained these Karen parents through a time of great disturbance and change. Although a collective narrative focused more on the Karen Christian Church and education, the most significant sentinel for individual narratives has been gardening. Anchored in a cultural tradition of farming, these Karen parents gained perspective and comfort in continuity and the potential of self-determination rooted in the land. Therefore, a science education program that focused on Karen gardening practices would be the most appropriate way for Karen parents to leverage their cultural knowledge and "author" a collaborative space in a cross-cultural learning community for their children.

Implications of Phase One for Phase Two

Emerging from visual and written narratives, the knowledge collected through the Karen parents' narratives take on a three-dimensional character that contributed more than objective knowledge to our cross-cultural learning community. Rather than a list of cultural facts about the Karen people in general, these cultural funds of knowledge were embodied by living people and their stories. Situating this cultural knowledge within the curricular design of an afterschool science learning program created space within the dominant culture of the classroom for permeable borders of knowledge. In addition, beginning this research with Karen parents established a baseline for Karen cultural

knowledge that Karen parents themselves identified as critical to the rebuilding of social and cultural capital in resettlement. It also extended legitimacy to the parents' knowledge for science literacy, and in the case of PSP, the co-teacher, extended legitimacy for the Karen language, a key literacy of the Karen culture, into the institutional classroom. Although I could not represent embodied knowledge for the Karen students, as a co-teacher working within the funds of knowledge model, I learned valuable information about the Karen culture from the parents' narratives. Finally, building a community of science learning that extended beyond the traditional classroom into the communities of participating students maximized the platform for advancement of Karen students in science literacy.

Although the purpose of working with Karen parents was to gather a baseline of cultural knowledge to supply a knowledge infrastructure for the afterschool program with Karen elementary students, this research demonstrated how unpredictable constructing knowledge with students can be. Although Karen students identified some of the same cultural and scientific artifacts in the Photovoice exercise that Karen parents identified, there was also distinct evidence of student resistance to the cultural narratives of their parents. For example, both Karen parents and students identified plants such as roselle as culturally significant for their way of life. Karen students in general did not challenge cultural discourses about nature or farming. However, in at least one case, a Karen student resisted the political narrative that had clearly been adopted by his family. On two occasions, James refused to talk about Karen nationalism within the cross-cultural learning community: once when the Karen pastor came to the afterschool program to teach about the Karen flag; and a second time when he displayed a photo of the Karen

flag hanging in his home but refused to talk about the meaning of the photo. Although Karen nationalism was a critical part of the counter-narrative Karen adults constructed to resist the dominant culture in Burma and Thailand, a counter-narrative that continues in some respect to frame their cultural identity in resettlement, the assumption that Karen students participate in the counter-narrative would be incorrect. Therefore, even though it was critical to represent Karen cultural knowledge with authenticity in the classroom in order to resist the dominant culture of the school, it was just as critical to allow students to identify their own cultural discourses. For this research with parents and students, it was important to recognize the tension that existed in our learning spaces, the points where parents' narratives diverged rather than converged with student narratives.

In this sense, the storied landscapes of the parents and the students, how they interacted with their environment, and the meaning they gave to places, existed authentically in spaces of convergence and divergence. In order to clearly define those spaces, both the parents and the students had to have a voice in the narrative. This research demonstrated that Karen students emerged as agents in science learning only after they engaged in the process of constructing cultural and scientific knowledge through the cross-cultural learning community. First they had to recognize the shift of power in the cultural terrain of science learning away from the dominant culture to a more equitable learning space, a space that they could populate with legitimate meaning. Within those spaces, they acted to define their own knowledge. However, do elementary students have the capacity to recognize dominant discourses apart from adults in the first stage of developing critical consciousness? This evidence of James pushing back against his father's political narrative would suggest that, in an equitable environment, he is

capable of identifying a dominant discourse that he does not want to own. Freire identified this critical first stage of emancipatory education as critical consciousness of the "world of oppression" (1970, p. 44). However, it seems clear in rejecting the Karen counter-narrative, James has perhaps become more vulnerable to complicity with the dominant culture his parents stand against.

Although the counter-narrative shaped by Karen parents in the refugee camps continues to influence their interpretation of events in resettlement and their cultural identity here, evidence of Karen students pushing away from this counter-narrative outweighs evidence of Karen students embracing their parents' stories. Within the school culture, narratives of displacement in distant lands did not seem to hold meaning for Karen students, even though the narratives seemed familiar to them. The cross-cultural learning community created cultural space that the students populated with meaning that was relevant for them. Students shared photos of their homes, their families, their friends, and food, but the history of the Karen people as remembered by Karen adults in their families did not enter the space. Only the Karen pastor through one visit and the Karen co-teacher represented the embodied knowledge of the Karen people. Other Karen adults would not come in and speak to the group. Although non-Karen students did not populate the learning space with their family histories, as members of the dominant culture, they can potentially derive representative power from belonging that is not necessarily available to Karen students. Establishing a learning space that begins at a point of cultural heterogeneity rather than acceding to the primacy of the dominant culture could create space for stories of displacement to gain legitimacy in the school culture. However, at the time and place of this research, the narratives of the parents that

contained meaning and power for sustaining their cultural identity in resettlement did not contain the meaning or power Karen students needed to re-build cultural resilience. Opportunities for integrating Karen knowledge into science learning were also limited by the premature closing of the afterschool program before the school garden project could begin.

Implications for advancing the model of science education for refugee students by integrating in the parents' scientific and cultural knowledge are clear. Future projects with Karen students could focus initially on relationship with the land, which functions as a keystone cultural characteristic identified by the parents' narratives to build social and cultural resilience for the Karen community. Based on the results of the first phase of this research, it seems essential to situate science learning for Karen students within familiar frameworks such as the Karen knowledge about growing food and raising livestock so that Karen students can participate in the co-construction of science knowledge using the discourses of their family and community as well as the Western discourses of science learning. In this way, the cultural identity that their parents have constructed through years of sustaining a counter-narrative in Burma and Thailand would be one stream of knowledge among many that help to shape the hybrid cultural identity of these Karen students. In addition, eliciting the expert knowledge of Karen parents in a learning community activity such as designing and building a garden on the school grounds could be the linchpin needed to bring embodied Karen science knowledge into the public school environment. Without this initiative, I believe Karen parents will continue to cultivate a climate of invisibility marked more by absence than presence in their children's education.

Phase Two: Weaving a Broader Tapestry of Embodied Knowledge with Karen Students

The process of legitimating Karen cultural knowledge within the mainstream discourse of Western knowledge in the context of this research project created space for Karen and non-Karen students to recognize the value of their culture within the larger discourse of science inquiry. By weaving cultural knowledge into science inquiry narratives about the moon, sound waves, and the natural history of places in the world, the students constructed a science learning terrain within which embodied knowledge replaced knowledge disconnected from a place or a people. It was this embodied knowledge, stemming from their own interests and experiences, past and present narratives rooted in other countries as well as in their home that enlivened science learning for participants. Students also legitimated their cultural knowledge through the Photovoice exercise by constructing visual narratives of their cultural and scientific knowledge embedded within their family and community knowledge. Finally, Mary's role as a co-teacher for the afterschool program represented a legitimation of Karen embodied knowledge within a traditional science classroom. By teaching the Karen language, she gained status as a holder of expert knowledge, and the language itself gained status as a legitimate literacy in the classroom. The research questions that guided this phase of the study were the following:

> How does the construction of a cross-cultural learning community that privileges Karen cultural knowledge affect the science learning of Karen student participants?
>
> How does the presence of Karen cultural knowledge represented by a Karen co-teacher and the Karen language affect how students position themselves within the learning community?

One of the objectives of this research project was to involve Karen parents and community members as much as possible in the learning community to infuse the program with authentic Karen cultural knowledge, and enable Karen students to build embodied science knowledge from the "multi-science" knowledge of their home community (Hammond, 2001). Science learning in this afterschool program was intended to be embedded in the self-sustaining farming culture of the local Karen communities. Karen families also worked together in the local community to build outbuildings for housing livestock. Preliminary plans for the spring semester of this program involved planting a garden on-site at the school under the guidance of Karen and non-Karen parent volunteers, and possibly building a greenhouse. This was to be the centerpiece of embodied science learning for the afterschool program. Students began to identify plants in their home gardens through the Photovoice exercise in the fall; science lessons had shifted in the spring to focus on the energy transferred from the sun to seeds. When the program was cut short, these plans were no longer viable. Therefore, the role of the Karen co-teacher became centrally important to the development of embodied knowledge for Karen students within the learning community. Essentially Mary (see narrative portrait below) embodied the Karen culture for Karen and non-Karen students in the program. Her instruction in the Karen language made the culture legible for the students. By serving as a co-teacher, she pushed back against the dominant teaching culture in the school, albeit unintentionally. By teaching the language as a literacy in the traditional classroom, she decolonized the classroom space politically and allowed the students to populate it with Karen knowledge that moved them into positions of experts rather than peripheral learners. Through her participation in phase one of the research,

the co-teacher experienced a transformation in her understanding of the value of the Karen language and she communicated that to student participants. In her closing interview, the Karen co-teacher responded to the question *Do you believe it is important for children to learn about their culture? Why or why not?* "It removes them from the Karen culture when they become completely American," she responded. "Then they would be ashamed, shut out by the Karen people. We have a song that talks about if we don't love our language, our people are going to be gone someday." In addition, all of the student participants responded positively to the closing interview question, *Is it a good idea to learn the Karen language? Why or why not?* The Karen students, as discussed earlier, now saw the language as an essential part of their culture, and the non-Karen students viewed it as an important tool to build cross-cultural understanding.

My friend Mary was a wonderful teacher in the program. Even though this afterschool program has been more of a challenge for her, I believe, than for me, she has kept her sense of humor and patience intact throughout. If she had been with me in more of those preliminary meetings with the school district representative, I might have been more patient too. From the beginning, when she and I first began meeting for language lessons at my request, she has been someone important in my life. She truly lives for others, her family, her friends, her community, whereas most of us just like to think we are unselfish but we really aren't. When I approached her about helping me with the afterschool program, she tried to tell me she was not a teacher. Although I had experienced her teaching gifts first-hand, I understood that the idea of teaching in the local elementary school probably was frightening for her. Even though the principal and teachers there seemed to appreciate her from the days when she used to volunteer there as a translator for the children, she and I both recognized we would be going in as outsiders. As a white female

from the south, I had much less understanding of this concept than she did and less right to own it. She has only been in this country for seven years. She spent twenty years, the first years of her marriage and had her first two children, in a refugee camp in Thailand. Of the two of us, certainly she had a more profound sense of what it meant to be an outsider. I felt I didn't have the right to impose on her in this way, but research project aside, I knew I couldn't do the afterschool program by myself. In our trial run in April, we had twenty students show up for the afterschool program, and it was difficult to manage all of those active personalities and still teach science. It may have seemed chaotic to me, but Mary's language lessons were a huge hit with the non-Karen students who came. When we began the program in earnest the following fall, some of the children who had been rising 5th graders for that trial program remembered the language lessons and the science experiment on seeds. Despite this early success, and even when the conflict with Fit Club cut our numbers in half, I felt overwhelmed and depended on her support to continue. One afternoon when she and I were driving the Karen students home after the program, she commented that their behavior in the program was, in fact, counter to the Karen culture. We joked about using the meter sticks to whip the students into better behavior, but I understood what she meant. Even though I had observed Karen children acting with independence and freedom in church and community events, their parents probably tightened control in public settings. Like any parents, they would wish their children to behave always with respect toward their teachers. Yet Mary herself taught with grace, gentleness and humor in the afterschool program, modifying students' behavior through encouragement rather than stern correction. By the end of the program, she and I were proud of what the students seemed to learn, and she agreed to continue holding sessions at her house when the school classroom became unavailable. Mary's garden was a work of art; whenever I visited her in the summer or fall, we would walk in her garden looking at all of the treasures. The expert knowledge that she and her husband would share with the students was a hybrid mix of Karen knowledge gleaned from their family history and adaptation to the land and resources of this place. (Narrative Portrait, Mary)

Viewing Karen Students through the Lens of Cultural Resilience

This research has served to broaden the current perspective on science education to include resilience. Using the metaphor of ecological resilience, this research engaged Karen families in the construction of Karen scientific and cultural knowledge before this knowledge was integrated into an afterschool program, thus seeking to restore agency and decision-making to a community recovering resilience after decades of displacement. A focus on resilience built on the work by Chinn and others in the field of social-ecological resilience who have looked to indigenous epistemology as a way to capture students' ways of knowing for science learning, and linked this research with emerging work on sustainability science.

In phase one, cultural resilience was defined as the ability of an indigenous people to maintain some measure of social infrastructure and cultural capital demonstrated by a productivity of lifestyle, ideology, and values in the face of profound displacement and loss. Using the metaphor of keystone species and the role they play in sustaining an ecological system, my research with Karen parents was developed around the idea that key cultural characteristics as identified by a local community could be essential to building cultural resilience in Karen students participating in a cross-cultural science learning community. Results from phase two indicated that Karen students in the 4th and 5th grades at this small rural school experienced the Karen culture as articulated in the afterschool program as an interruption in their regime shift, to borrow terminology from the ecological resilience analogy. As the interest of the Karen students grew and developed for characteristics of the American culture, their interest in the Karen culture, particularly within the learning parameters of the institutional school setting, seemed to be declining. The exception seemed to be the Karen language, which offered Karen students the opportunity to exhibit expert knowledge within the learning community.

According to the guidelines established by Turner and colleagues (2008), recovering cultural resilience involved a process of recapturing values and integrity from family and community narratives, situating these in historical and present day narratives, and establishing a means of moving forward as actors with decision-making power for the future. Students began to realize these objectives in the afterschool program by demonstrating expert knowledge in the Karen language lessons; talking with some reservations about their culture in front of non-Karen students; and acting with agency in the language lessons and in science learning. Turner and colleagues (2003) referred to

the area where two ecosystems meet and overlap, such as an estuary, as an ecological edge: *A well-known characteristic of ecosystems is that these edges often exhibit high levels of productivity and species richness or biodiversity* (Turner, Davidson-Hunt, & O'Flaherty, 2003, p. 440). They suggested that a convergence of cultural knowledge systems into an "edge community" can produce a *richness of knowledge and practices that enhances the resilience of local societies* (Ibid.). This rich terrain of diverse knowledge could impact Karen students' learning identities by yielding a generation of community leaders who are more resilient than the average community resident who has been raised with only one language, one culture, and one perspective. I suggest that the cross-cultural learning community developed in this research provided space for some significant cultural adaptation and restoration for Karen students. In the same way that a mangrove forest recovers from a hurricane because the sentinel species of that ecosystem sustain basic functionality, the Karen language and culture transposed into a science learning environment enabled Karen students to re-discover selected portions of the embodied knowledge of their families, such as the language, and reinstate them to a place of value in their hybrid cultural identities. Moreover, I suggest that this exercise in developing a hybrid cultural identity which retains strong values and meaning from their home culture in the face of social and academic pressures to discard this knowledge creates the opportunity for Karen-American students to position themselves not just as science learners, but as rich repositories of diverse streams of knowledge and perspectives, more able to synthesize ideas and access multiple resources because of this higher level of resilience. Akerson's recent study of 3rd graders seems to support this idea; they concluded that a Native American student who was able to speak with

confidence about his culture within the context of a science class seemed to be able to grasp NOS ideas at a higher level of understanding than his classmates due to a higher level of resourcefulness (Akerson, et al., 2014).

Viewing Karen Students and Science through the Lens of Critical Pedagogy of Place

Place-based science learning in this project not only situated the construction of scientific knowledge within a specific historical context, place and community, but also brought the Karen community into more equitable relationship with the school community. For this Karen community struggling to maintain their own culture in a predominantly White rural area, the process of decolonization and re-inhabitation both within the traditional learning space of a classroom and within institutionalized understanding of scientific knowledge positioned the Karen co-teacher and the Karen student participants at the center of science learning rather than on the periphery. The cultural knowledge of the Karen community embodied by the teacher and shared through language lessons was central to the construction of knowledge, not peripheral (Marshall & Toohey, 2010). The re-inhabitation of institutionalized classroom space took place through the construction of cultural knowledge and scientific knowledge simultaneously. In addition, recognizing the science of self-sustainability through cultivation of the land and animal husbandry as valid science knowledge alongside the physics of force and motion in the afterschool program contributed to the understanding of all of the participants that the Karen people were rooted in science through their experiential knowledge. In the Photovoice exercise, participants learned to expand their previous ideas of what constitutes science to include photos of plants, animals and even a skeleton. By the conclusion of the Photovoice focus group, Karen and non-Karen students alike

were able to draw from their everyday experiential knowledge to think about science. This research project has broadened the perspective of Karen adults in addition to the perspective of participating students in thinking about science in everyday contexts. This project contributed to the current understanding of critical place-based pedagogy by applying the theoretical construct of decolonization and re-inhabitation to a traditional science learning space and to a mainstream understanding of scientific knowledge. In this project, scientific knowledge was not displaced; rather, it was rooted in the everyday knowledge of participants and in the self-sustaining knowledge practiced by the Karen community through a strong connection to the land and the natural resources of their environment. Moreover, the process of re-inhabitation of the science learning space with hybrid cultural knowledge that took place was in resistance to the discourses of the dominant culture. Instead of teaching Karen knowledge interpreted through the lens of a member of the dominant culture, such as myself or other teachers at the school, Karen participants brought their own embodied knowledge into the learning community.

In their recent study on English language learners in science education, Buxton and Lee (2014) identified a model for effective science instruction that links hands-on activities with cognitively challenging science inquiry practices. Within this model, key features included building on students' lived experiences at home and in the community and bringing in family and community members to contribute culturally to literacy events at the school. Buxton and Lee suggested that curriculum designers and educators have limited knowledge of the worldviews and cultural approaches to the production of knowledge of the varied ethnic communities that populate schools in the United States today, yet this knowledge is essential to bridge the achievement gap that students who are

linguistically or culturally marginalized experience in our schools. In the years 2008 – 2010, over 53,000 refugees from Burma came to the United States (National Clearinghouse for English Language Acquisition, 2011). This research has contributed to the base of knowledge about the Karen people and their culture, and how that knowledge can be integrated in to a model of science learning and scientific practices for Karen elementary students that could effectively jumpstart their achievement in science related fields.

In addition, this research has contributed to the discussion on cross-cultural education with refugee students, particularly with regard to increasing scientific literacy in refugee adults and children. The goals of this research project were carefully aligned with the goals of the Next Generation Science Standards. Although the NGSS spent a disproportionately small amount of space addressing the needs of ESL students, the authors were clear that the ultimate goal is scientific literacy for all citizens in the United States. The Karen adults who participated in my pilot study were also clear in their understanding of the long-term objective of education: Now that they are citizens of a democratic country, education can provide an opportunity for their children to achieve a rich and fulfilling life. One goal of this project was to make science more legible for Karen children so that they could begin to see themselves as scientists, both now and in the future, enabling them to step eventually into STEM careers.

Within the afterschool program, decolonization of the academic and social spaces occurred overtly through the rearrangement of our physical learning space and through inquiry-based science investigations which allowed for greater agency, and covertly through the re-distribution of power to the Karen students. As teachers, Mary and I gave

intentional directed attention to the Karen students as agents in their own self-identity enterprise. The learning community apparatus was sustained by a climate of reciprocity in which we solicited the informed knowledge of Karen students, thereby extending to them the weight of responsibility for acting as scientists. We challenged the assumption that emergent bilingual students struggled academically to keep pace with non-Karen students. Instead, we acted from the assumption that Karen students could act as agents in science learning using the embodied knowledge of their culture. Karen students had become fluent in English, and immersed themselves in the culture of play and learning present in the dominant mainstream of white American students. The cross-cultural learning community offered Karen students a third space, an in-between space, in which they could recover cultural resilience, the ability to sustain the integrity of their own hybrid culture as Karen-Americans, through a commitment to the Karen language and embodied learning in that community.

In this research project, the most commonly used definition of NOS as a way of knowing science was accepted with the caveat that an understanding of the use and production of scientific knowledge emerges from a learning terrain in which contextually authentic science learning is inextricably connected to the cultural knowledge of the students. Therefore, this research welcomed a wide terrain of cultural knowledge to inform science learning, and the indigenous epistemology of Karen students was privileged within the physical and political spaces of the afterschool program. In this way, the assumption that the culture of science existed within the dominant culture of ways of knowing was challenged. Multiple epistemologies, those of students and teachers, were applied to the construction of scientific knowledge within the cross-

cultural learning community. Contextually authentic science inquiry allowed students to identify problems within specified categories of science learning based on their observations and experiential knowledge, construct testable questions, and gather data from which to construct explanations. For Karen students in particular, the scientific practice of constructing explanations based on evidence gathered in science inquiry projects proved to be a key characteristic of re-inhabiting the learning space inside the afterschool program. The science inquiry process enabled Karen students who had leveraged their understanding of the Karen language to claim higher academic status in the learning community and exercise agency in some of the inquiry projects.

Other Karen students who did not seem to be leveraging a higher academic status in the community through the language lessons also seemed to respond to the opportunity for re-inhabitation that the inquiry process offered. For example, one of the shyest Karen students, Hannah, brought in a jar of water from a stream near her house so that we could test the acidity level. Although Hannah was not one of the students who contributed to the discussion very often during the language or science lessons, testing the stream near her house made the science lesson on the water cycle relevant for her.

Building on the model established by Chèche Konnen scholars and others that situated inquiry-based science education within a cross-cultural learning environment in which students and teachers constructed scientific knowledge together using multiple epistemologies, this research project not only successfully applied this model to a first-generation refugee community possessing limited social capital in early resettlement, but also demonstrated the ability of Karen elementary students to leverage cultural knowledge such as the Karen language to position themselves as agents in science

learning. These results have implications for science education research with emergent bilingual students that has embraced an equity agenda. In addition, this research has implications for the call by Walls and others to appropriate an equity agenda for future research on elementary students and their grasp of NOS views, a current marker employed in science education to indicate scientific literacy.

The work done by Chèche Konnen scholars (2010, 2012) to identify the institutional science-culture divide present in school science and the pathology of powerlessness endemic within that divide for marginalized students has opened space for a new meaning-making discourse that connects the streams of indigenous knowledge and everyday knowledge. Applying this constructivist model of science learning to the cross-cultural learning community that developed within our afterschool program allowed Karen students to engage as agents in science inquiry from the platform of their cultural knowledge. In that the Karen language was legitimated as a literacy within the science learning program, Karen students were able to leverage this expert knowledge from their family funds of knowledge to gain greater academic and social status in the community. In addition, we successfully challenged the deficit discourses for behavior and learning that were based in the dominant culture of this small rural elementary school, such as a deficit assumption of Karen male student behavior and a deficit assumption of the dovetail connection between Karen students' linguistic ability and their academic ability. By decolonizing the physical and cultural space used for learning, the borders of culture and science education were made more porous, and Karen students could construct their own knowledge within emancipatory spaces. Instead of being directed by teacher-facilitated border crossing, the learning community allowed them to interact with one

another and the teachers in order to construct knowledge. The co-construction of scientific knowledge took place through contextualized authentic scientific inquiry within the students' own social and cultural literacies. Students carried out experiments based on their observations, and crafted scientific explanations supported by data from the experiments. Although they learned the language of science inquiry, they also learned the Karen language and adopted discursive identities of various cultural identities, American and Karen. These literacies were blended, porous, not essentialized or separated out as distinct; my research documented the confluence of these literacies into a decolonized space.

This dissertation also built on research in cross-cultural science education for linguistically and culturally marginalized students completed by Hammond (2001), Upadhyay (2009), Buxton, Allexsaht-Snider & Rivera (2013) and Chinn (2009, 2010) that suggested incorporating home languages and indigenous knowledge into the science learning of students, their families, and teachers moved authentic scientific inquiry into emancipatory spaces for science education. In after-school programs, weekend programs, and cultural immersion programs that lasted several weeks, students in previous research projects constructed embodied science knowledge through science inquiry with families and teachers through the shared learning objectives of a community of practice. A community-based construction of hybrid cultural knowledge and scientific knowledge allowed more complex meaning to emerge than would have been possible in a traditional science classroom with didactic instruction. Karen students emerging as agents in science inquiry, challenging the scientific reasoning of non-Karen students, and claiming the right to argue their own reasoning is evidence of a more complex

understanding of scientific knowledge, one that begins to embrace the epistemology of science. This emancipatory process was enabled by the presence of a Karen co-teacher, who embodied Karen cultural and scientific knowledge for the learning community and instituted the Karen language as a literacy in the program. If we had had the opportunity to expand the program to include Karen families, as we originally had intended in this project, either through a parents' night in which parents could view the work of their children, or through the planning and cultivation of a school garden, the embodied knowledge of the learning community might have deepened to include more of the self-sustaining "multiscience" practices of the Karen people (Hammond, 2001; Upadhyay, 2009).

Using an instructional strategy of explicit instruction and reflection on science and culture seemed to bridge several gaps: the nature-culture divide (Bang, et al, 2012); the equity disparity between students who cannot access science ideas due to linguistic or cultural barriers and students engaging with science from the dominant perspective shared by the majority of teachers in the United States; and the gap between students' understanding of culture, both their own and the culture of science, and teachers' understanding of the same. This research suggests that elementary students in general require explicit instruction and reflection on culture in order to articulate their own ways of knowing in addition to explicit instruction and reflection on authentic science in order to grasp the use and production of scientific knowledge. For Karen students who were in the process of constructing a hybrid cultural identity that draws from non-dominant streams of knowledge, the legitimation of Karen cultural knowledge within a science learning space was critical. Situating science learning within a cross-cultural learning

community allowed Karen and non-Karen students to construct their own cultural identities in addition to their identities as co-constructors of scientific knowledge.

Implications for Science Teaching and Teacher Education

This research also has implications for prospective teacher education and professional development for seasoned teachers. In science education research, there have been few examples of the decolonization and re-inhabitation of traditional science learning spaces. The research by Upadhyay (2009) on the integration of Hmong cultural knowledge into science learning by a Hmong teacher is one of the few examples. The majority of prospective and experienced science teachers in the United States are White, middle-class monolingual females, who have a low retention rate in areas where the student body is culturally diverse (Cochran-Smith & Zeichner, 2010). In the Executive Summary of the Report of the AERA Panel on Research and Teacher Education, the authors presented teachers' knowledge frames and belief structures as the "filters through which their practices, strategies, actions, interpretations, and decisions are made" (2010, p. 21). In other words, those prospective teachers who do not share a cultural background with their students or who have not had experiences designed to shift their paradigm of understanding science teaching and learning to accommodate the needs of a diverse student body cannot be considered pedagogically prepared to teach in a classroom in which there is a high percentage of ethnic minority students (Gay, 2002). Although studies designed to reduce prejudice and build capital for equity pedagogy in prospective teachers yielded positive short-term results, it was clear that the strong connection between the beliefs and attitudes of teachers and their willingness to adapt their curriculum and pedagogical practices to meet the needs of culturally marginalized

students remains a pressing issue for teacher educators today (2002, p. 21; Cochran-Smith & Fries, 2010, p. 100; Jones & Carter, 2007, p.1067).

Although we were not successful in this project in extending our cross-cultural learning community to teachers and administrators in the elementary school that hosted our project, the model of constructing embodied scientific knowledge within a cross-cultural learning community that embraces family funds of knowledge as well as community funds of knowledge could provide transformative space for teachers as well as students in the classroom. This research has demonstrated the effectiveness of having a Karen co-teacher who embodied Karen cultural knowledge playing a key role in the learning community. Through her teaching and her presence as a legitimate stakeholder in expert knowledge of the Karen language, the Karen students were able to leverage their own knowledge of the language to advance in status in the learning community, and even to act as agents in some instances. Without her participation, embodied representation of Karen knowledge would not have been possible, I would argue. Although there are a few examples of teachers experiencing a shift in cultural perspective through the imposition of exercises designed to increase cultural responsiveness, only cultural immersion experiences have proven successful in shifting teachers' perspectives over the long term (Chinn, 2006; Greenwood, 2001). Immersing teachers or prospective teachers in alternative cultures over an extended period of time essentially could displace them from a position of control and power that participation in the dominant culture ensures. Transformation could occur in this vulnerable space. For the Karen community, who value hospitality, hosting teachers in their homes for a meal would be a simple way

to create a climate of reciprocity in learning outside the classroom that could contribute to building the same within the classroom.

Directions for Future Study

Future research in this field could benefit from longitudinal and latitudinal extensions. Although I had limited success in recruiting Karen parents and community leaders to serve as knowledge-keepers and stakeholders within the learning community of their children, I believe future research with Karen adults and students should strive for this gap in the learning community to be filled. I was able to persuade Mary to co-teach the afterschool program with me, but I was unable to persuade any of the other mothers to join us. Mary and I developed a friendship over the course of two years of Karen language lessons, illness, multiple visits to community gatherings, and many shared projects such as the service-learning project with youth from our church to build a chicken coop on the community garden site. The Karen community welcomed me primarily because we shared the language of Christianity, albeit different traditions, but PSP and I have developed a rich friendship over the course of the project. Within the protection of this reciprocal relationship, she committed to helping me with the afterschool program. However, even though I solicited all of the parents of the children to come and participate in the learning community, only the Karen pastor visited one time to speak on the Karen flag. If this project could be extended laterally to include more community members, in the same way that Lori Hammond's (2001) research with the Mien community did, or in the way that Buxton and Allexsaht-Snider's (2013) research with the Hispanic community has included families in Saturday science days, then I believe the learning community would produce richer knowledge. Similarly, if this

research had not been unexpectedly terminated before the spring gardening part of the project could begin, I believe we might have been able to involve more Karen parents and their scientific knowledge, and applied the results from phase one more interestingly to phase two. If this project could have been extended for one full year or even for two years, the results might have been more representative of the Karen community's construction of knowledge in a hybrid space.

This project could also be extended to include cross-cultural science education for seasoned teachers through professional development and prospective teachers. Research on prospective science teachers' cultural values and beliefs has indicated that many teachers struggle to see themselves as scientists (Hancock & Gallard, 2004; Akerson, Buzzelli, & Donnelly, 2008). Many prospective science teachers experienced science teaching as a passive transmission of knowledge in keeping with a linear behaviorist model; as a result, they believe that students learn science by being taught objective facts about science (Jones and Carter, 2007). If their early socio-cultural background has limited their own understanding of the production of science knowledge in addition to the cultural differences they might encounter in the classroom, how then can they be expected to guide a diverse student body in the process of authentic scientific discovery? Within the framework of a cross-cultural learning community, prospective teachers could participate in community-based culturally-embedded science learning. Although not a cultural immersion program, this pedagogical approach could offer long-term partnership with parents and students in the Karen community. Moreover, through participation in the community of practice, experienced teachers, parents and community leaders can provide scaffolding for prospective teachers to engage in cross-cultural learning and

inquiry-based science learning successfully. Prospective teachers who would normally be placed with one mentor teacher in their student learning experience could instead engage in a group curriculum-building and reflection process that brings in many different voices and perspectives from the communities surrounding the school.

In addition, research with the Karen students and conceptualization of NOS embedded within cultural knowledge could be extended to include more aspects of NOS. This research looked primarily at the tentativeness of scientific knowledge and how imagination and creativity could be applied to the use and production of scientific knowledge within the students' own epistemologies, as well as examining the cultural and social embeddedness of scientific knowledge in a way that "de-settled" the assumption that the cultural context of scientific knowledge was limited to that of the dominant culture. However, other aspects of NOS could also be addressed in the context of this research, such as more attention to the empirical nature of scientific research other than the construction of scientific explanations, or a closer look at the subjective nature of the development of scientific knowledge. Also, it would be interesting to establish some measure of transferability for this research by attempting to duplicate it in diverse settings, possibly with larger numbers of students and adult participants. Leon Walls (2012) has challenged the exclusive viability of the VNOS as an instrument to measure how well students from diverse cultures are grasping the ideas of NOS. It would be interesting to extend this line of inquiry, continuing to develop the use of arts-based research methods such as Photovoice to create space to critique the dominant worldview and provide alternative and more appropriate ways of assessing how elementary students are accessing what they perceive to be the culture of science. In fact, based on this

current research, a new line of inquiry could be developed that continues to challenge the viability of a mono-cultural approach to the study of science.

Continued work on establishing a connection between social-ecological systems and the cultural resilience of indigenous people could also be developed from this research, building on the work done by Pauline Chinn and Lyn Carter on sustainability science and resilience. I believe this has become an important construct for researchers in science education who are grappling with indigenous students and equity issues. This research has demonstrated that the keystone cultural characteristics articulated by the parents in reference to the continued education of their children could be the bricks and mortar of a Karen counter-narrative that extends from their history into their present situation in resettlement and possibly into the future as their children become adults. As noted in the history of the Hmong people, some communities found a counter-narrative necessary to push back against the pressure in the United States to assimilate to the dominant culture, particularly in education. It could be argued from this research that Karen parents have sustained the counter-narrative they developed in the refugee camps because they found it necessary to resist assimilation in the same way. If this is true, and future research could examine this more closely in paired parent-student frameworks, then creating space within institutionalized education for the Karen culture to be legible and even legitimate knowledge could be a critical part of sustaining a counter-narrative that allows the Karen people to develop their own hybrid Karen-American cultural identity, separate from an American identity in ways that they choose as part of reclaiming resilience through self-determination. Continuing to apply a critical perspective in research with the Karen through place-based pedagogy would be essential

in this case; the process of decolonization and reinhabitation of physical and academic spaces, pushing back against the dominant cultural narrative in education, could facilitate the ongoing praxis that would be necessary to rebuild and sustain cultural resilience.

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Appendix A

This narrative portrait was constructed immediately after an interview session and a 2-hour excursion to collect photos on the same day. It is truly a mosaic of quotes from the interview, conversation during the excursion, and bits of conversation from other occasions (for example, the comment about bananas was made during a visit to PSP's house when she was terribly ill). The researcher's own relationship with the participant colors the portrait; the researcher is blatantly present in the narrative (Lawrence-Lightfoot & Hoffmann-Davis, 1997). The goal was to re-present the participant as an embodied actor in the construction of her own narrative portrait. To that end, blocking out names and personal information to protect the identity of the participant proved futile. This could be counted as a limitation for this form of analysis; although creative, it does not protect the identity of the participants.

Citizen

What does it mean to be a citizen in this country? For me, it is a taken-for-granted thing. Voting is an inconvenience because it means one more stop after work. The ads on TV and the radio are aggravating to say the least. No one keeps campaign promises anymore. Can Obama throw a wrench in the war machine? Will he? I have lost faith in politicians to change the world for the better.

Pa Saw Paw has passed her citizenship test. She had to wait five years to take it, and now she has passed it. When we were in the third doctor's office hoping and praying this one would finally know why she couldn't eat or drink anything without pain, she said she had to be better by March 15, because that was when she was going to Atlanta to take her U.S. citizenship test.

When I congratulated Pa Saw Paw on passing her test, I asked what citizenship means to her. She said that living in Thailand in the refugee camp was difficult: they were not allowed to apply for citizenship in Thailand. Thailand does not have a rule like the U.S. that allows people to apply for citizenship after five years. A fence circles the camp. If Karen refugees are caught outside of the fence, they can be arrested and deported back to Burma. If they returned to Burma, the government would have them killed. The government of Thailand wanted all of the Karen people to return to their own country.

If you ask Pa Saw Paw where she is from, she will tell you "Karen State." Karen State is a long sliver of land along the Thai-Burma border. Eh Kaw Htoo, Pa Saw Paw's husband, says that one day the Karen people believe they will be an independent nation. They will be able to live in peace in their own country without fear of military raids.

We walked outside to look at Pa Saw Paw's garden. She is feeling much better and can walk on her own from the house to the barn outside. Last fall, when friends and I shared an evening meal with Pa Saw Paw and her family, she showed us around her garden with pride. Living green plants clung to every surface and each other. She had onions, tomatoes, hot peppers (the Karen like hot spicy food, but Pa Saw Paw inherited a sensitive stomach from her father), and beans. Trellises covered in green vines and great purple bean pods reached out from the top of the fence into the yard. Several times when I came for my lesson, bunnies were grazing in the yard, alongside chickens. Eh Kaw Htoo keeps chickens, at the house and at their community's garden down the road on Jubilee's land. Once when the youth group came for a meal, Eh Kaw Htoo showed them how to make a trap out of branches to catch garden invaders. He could also put a chicken to sleep by tucking its head under its wing, and shaking it up and down while singing in Karen. One of the kids copied the trick while we were there that evening. Many times when I would arrive on Friday evenings for my language lesson, I would see Eh Kaw Htoo leaning on the fence outside talking to the chickens. Today he was trying to keep two roosters from killing each other.

Now Eh Kaw Htoo and a young Karen man whom I don't recognize are out in the garden turning the soil for spring planting. Pa Saw Paw shows me where she will plant kale, and beans, purple and green, long yellow squashes, and bitter melon. I had noticed a tent pitched in the backyard when I pulled up that afternoon, and now Pa Saw Paw walked me over to it. Inside she had tiny plants in starter boxes. "This is my greenhouse," she said. Jack, her second-born, tugged on my arm. "I water all the plants," he said proudly.

I offered to drive up to the community garden with her. The kids wanted to come but Pa Saw Paw waved them over to their father. "But my mother wants to come," she said. Every time I see Pa Saw Paw's mother, she is smiling. She is a very slight woman. Once when it was very hot in the summer, I saw her out in the yard rubbing a branch of something against a stone, and then rubbing the residue on her cheeks. Pa Saw Paw's family did not use air conditioning. It was sometimes a struggle for me to focus on the language lesson. She jumps in the car with us and we drive through Jubilee's farm before going up to the garden. Pa Saw Paw greets friends along the way. Pa Saw Paw has many friends, Karen and American. The couple we meet along the Jubilee road are actually from Canada.

Pa Saw Paw remembers the house she and her family first stayed in when they came to Jubilee from the airport. She has told me that the houses in the refugee camp were very close together, with bathrooms and wells for drinking water placed very close together. Very few people were able to grow anything in the absence of space, and the children were sick very often. This place is surrounded by trees, and the houses sit nestled at discrete distances. They are painted bright colors. On one porch, despite the cold March weather, several people are gathered in conversation. "This reminds me of home," Pa Saw Paw says. "Well, yes," I responded, "except we don't have jungle here or bananas growing on the trees, and it's freezing cold." "Or waterfalls," she says. Once when I was visiting Pa Saw Paw, Eh Kaw Htoo held up a banana and said that this fruit doesn't taste anything like the bananas they had at home. At home they could reach

up and pluck a ripe banana from the tree and the flavor was rich and full. The bananas they have here, he said, are harvested before they are ripe and they die slowly on the trip to the grocery store.

Pa Saw Paw remembers living at a tiny apartment in the school at Jubilee when their family was trying to move back here from Atlanta. She served as interpreter for the next group of Karen refugees who came to stay for a few months to learn the ways and language of America. What is difficult about living here in America? I asked her. She answered slowly that if a person does not know English, then it is difficult to live in America. She began learning English as a small child. The schools in the refugee camps taught the children three languages: English, Burmese, and the Thai language. Some Karen had lived in Thailand for years and spoke only Thai. They were not residents of the refugee camps. Pa Saw Paw's sister had married a Thai Karen man. The difficulty with that, she explained, is that she doesn't get to speak or read in her own language.

When we finally reach the garden, several Karen families are there ahead of us. Jubilee donated this land to the Karen community so that they could develop a community garden. On Saturdays in the summer, families come out with their children to work in the garden, eat together on the grass, and socialize. Now the ground is turned over, waiting for spring seeds. Giant water coolers stand above the ground to feed the irrigation system. In the fall when we were here, there was a magnificent patch of hot peppers in bright colors along one side of the garden. One of the kids from our church was dared to eat one of the peppers, and he threw up violently as a result.

Pa Saw Paw's mother has jumped out of the car ahead of us and is striding purposefully along the path in-between plots. Pa Saw Paw points out the plots that her mother has reserved for their family for the spring planting. We walk through the garden to the far side, where a herd of goats lived in the summer and fall. Pa Saw Paw had a goat that was expecting a baby. Now there are no goats here. "They have run off into the woods," she says. I wonder if maybe they were carried off into the woods by bigger

critters. The flock of chickens looks a bit thinned out too. In the fall, the chickens were arrogant and gorgeous, a variety of brightly-colored chickens from Cuba, Eh Kaw Htoo told us. Now they didn't seem so bold.

On the way back into town, we passed another Karen woman, distinctive in her long skirt and flip-flops, a child on each hand, walking up to a store in Comer. The sign caught my eye. It was written in Sgaw-Karen. "What is that?" I asked Pa Saw Paw. We pulled up and met the beaming owners, the pastor's son and his wife. It was a modest general store, with a cash register propped on a box, and shelves stocked with packaged foods from Thailand. In the corner, great bags of rice were stacked up like bales of hay. I wandered through the aisles, marveling at what could be pressed into plastic and shipped from across the world. They would be having a grand opening on Saturday, the pastor's son said. On the way out, Pa Saw Paw commented that they were afraid no one would shop there. I promised to come next week with cash to buy some of the exotic food.

I had last seen the pastor's son at Jubilee's tenth birthday party. Jubilee is Pa Saw Paw's first-born child, named for the place that gave them hospitality. It is the Karen tradition to call adults by their first-born child's name; for example, Pa Saw Paw is really called Jubilee-mo. On the day before Jubilee's party, Pa Saw Paw was staying up late to cook and to finish translating my consent form for this project. She drank two cups of coffee, which she never drinks, and they had to run her to the hospital for high blook pressure. She had trouble catching her breath. Two days after that, she became very seriously ill. It turned out she had a bacterial disease, but I always thought my consent form contributed to her illness.

Our last stop was the elementary school, where Pa Saw Paw has been volunteering for the past year in the afterschool program. Many of the Karen families send their children to the afterschool program to get help with their homework. In January, Pa Saw Paw and I taught a class on the Karen New Year. Pa Saw Paw sang a simple national song and wrote the words on the board in Sgaw-Karen. Most of the children speak Karen at home, she told me, but they don't know how to read or write it. I

talked about the history of the Karen Nation, and the meaning behind the national flag. My husband and I had joined the Karen community at Christmas for their celebration out in Vesta, Georgia. They had a two-hour worship service outside that began at 8 in the morning. We barely made it. Everyone was bundled up in blankets. There were kids singing songs, and adult groups that sang also. Several men spoke. I was impressed to see the men on the platform wearing the traditional skirts and short-sleeved woven shirts. Afterward, there was a volleyball match and traditional dancing performed by a group that came in from Atlanta.

I asked Pa Saw Paw what she liked about living in America. Education, she answered. Education is the answer. What do you see for your future, I asked. Improving her English so that she can pass the GED. What after that? Nursing school maybe. What about your children's future? "I would like one to be a pastor," she said. Maybe Jack. What about Jessica, I asked, looking at her three-year-old in a pink coat and dress. Maybe a teacher. What does citizenship in the U.S. mean to you? Freedom, she answered.

Appendix B

Interview Protocol – IRB proposal

Good afternoon. Thank you again for agreeing to participate in this pilot study. The information that you contribute will be used in a study designed to explore how you have been able to retain the cultural knowledge and language unique to the Karen people while blending into the culture and language here in the United States.

This interview should take about one hour. Everything you say will be kept confidential. Pa Saw Paw (or Eh Kaw Htoo) is present to help us understand each other better in case there are language difficulties. I will be audiotaping our conversation in accordance with the consent form that you signed at the beginning of this project. If you are not comfortable answering one of the questions or do not feel you understand the question entirely, we can skip that question and move on to the next one.

What is your name?
How long have you been here in the United States?
Where were you before you came to the United States?
Where are you originally from?
What do you remember about that place?
What work did you do there?
Tell me about your family there.
What family do you have here?
What work do you do here?
Can you tell me three things that you like about living in Georgia?
Can you tell me three things that are very different from your life before in _____?
Are there any things that you do here that are the same or very similar to the things you did in your original country?
What language do you speak in your home?
Have you taken any English language classes, in your country of origin or here?
What plans do you have for the next year? For the next 5 years?
What parts of your life do you consider to be uniquely Karen?
What parts of your life now do you consider to be uniquely American?
What parts of your life are both Karen and American?

Thank you for taking the time today to speak with me. I appreciate the thoughtfulness with which you have answered my questions. I am sure your contribution will help to make this project beneficial. If you have any questions about this interview, you can contact me at 706-206-3690.

Appendix C

Focus Group Protocol Applied within a Photovoice Project

Reference: Wang, Caroline C. (1999). Photovoice: A Participatory Action Research Strategy Applied to Women's Health. *Journal of Women's Health 8*(2), pp. 185-192.

Photovoice is a participatory action research (PAR) method based on feminist theory and innovative approaches to documentary photography. It has been used in the United States and extensively in England as a tool to empower marginalized people to work for change by representing their own realities through photography and presenting this in a public forum to policymakers. The three main goals of Photovoice, as defined by C. Wang are: to enable people 1) to record and reflect their personal and community strengths and concerns, 2) to promote critical dialogue and knowledge about personal and community issues through group discussions of photographs, and 3) to reach policymakers (p.185). This method allows people who have a limited public voice to represent themselves to the public. The Karen refugees with whom I work are limited by language and cultural barriers. This project would allow them to define their own "creolized" cultural identity through visual representation. Within the context of this pilot project, these visual representations will not be made available to the public or to policymakers.

At the organizational meeting with the Photovoice participants, we will discuss the use of cameras and the ethics of using cameras to capture people's identities. We will review the consent forms and discuss how to protect people's privacy, recognizing that anyone has the right to refuse to have their photograph taken. Photovoice also has developed the practice of returning photos to the community members, in this case, the Karen couples, when the project is completed. That will be an option that participants can choose in this project.

The prompt for taking photographs will be: *Take pictures of the things or people who are most important to who you are as a Karen person.* After the first set of photographs have been developed, there are three stages that unfold in the focus group discussions: selecting photographs that hold significant meaning; contextualizing the photographs, or storytelling; and codifying issues or themes that emerge from the discussion. Questions that I have considered offering during the focus group discussions are:

(Directed to each photographer)
What do you see in this picture?
What does this photograph make you think of?
Why did you select this photograph out of all of the photographs as important to you?
What does this photograph say about you? About the Karen people?
Does this picture make you think of Burma, Thailand or America? Why?

I hope to be able to repeat this procedure a second time before the project is completed. At the end of the project, the group will discuss relevant themes that have emerged that are common and/or unique to the group. They will then decide on a format in which to present their findings to the larger Karen community, if they choose to do so. In contrast to the stated intent of Photovoice of influencing public policy through a public presentation of the findings, this pilot project is for the small group's edification, and will not be presented publicly. My goal with this pilot project is to judge how effective this methodology is with the Karen people. If it proves effective, then I would like to use it for my dissertation project.

Appendix D

Lesson Plans

Susan Harper
Lesson Plans
Karen culture, language and science afterschool program
September 2014 - January 2015

Big Science Idea: Energy

Learning Performances for this unit:
Students construct a scientific explanation that includes a claim about how seeds get the energy to grow and evidence from observations that seeds grow from air and water.

Students construct a model that represents their explanation of how energy moves from the sun to seeds to plants and to the organisms within that food web.

Georgia Standards
S4CS3. Students will use tools and instruments for observing, measuring, and manipulating objects in scientific activities utilizing safe laboratory procedures.

a. Choose appropriate common materials for making simple mechanical constructions and repairing things.
b. Measure and mix dry and liquid materials in prescribed amounts, exercising reasonable safety.
c. Use computers, cameras and recording devices for capturing information.
d. Identify and practice accepted safety procedures in manipulating science materials and equipment.

S4CS8. Students will understand important features of the process of scientific inquiry. Students will apply

The following to inquiry learning practices:

a. Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.
b. Clear and active communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.
c. Scientists use technology to increase their power to observe things and to measure and compare things accurately.

d. Science involves many different kinds of work and engages men and women of all ages and background.

S5CS1. Students will be aware of the importance of curiosity, honesty, openness, and skepticism in science and will exhibit these traits in their own efforts to understand how the world works.
a. Keep records of investigations and observations and do not alter the records later.
b. Carefully distinguish observations from ideas and speculation about those observations.
c. Offer reasons for findings and consider reasons suggested by others.
d. Take responsibility for understanding the importance of being safety conscious.

S5CS4. Students will use ideas of system, model, change, and scale in exploring scientific and technological matters.
a. Observe and describe how parts influence one another in things with many parts.
b. Use geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories to represent corresponding features of objects, events, and processes in the real world. Identify ways in which the representations do not match their original counterparts.
c. Identify patterns of change in things—such as steady, repetitive, or irregular change—using records, tables, or graphs of measurements where appropriate.
d. Identify the biggest and the smallest possible values of something.

S5CS5. Students will communicate scientific ideas and activities clearly.
a. Write instructions that others can follow in carrying out a scientific procedure.
b. Make sketches to aid in explaining scientific procedures or ideas.
c. Use numerical data in describing and comparing objects and events.
d. Locate scientific information in reference books, back issues of newspapers and magazines, CD-ROMs, and computer databases.

S5CS6. Students will question scientific claims and arguments effectively.
a. Support statements with facts found in books, articles, and databases, and identify the sources used.
b. Identify when comparisons might not be fair because some conditions are different.

The Nature of Science
S5CS7. Students will be familiar with the character of scientific knowledge and how it is achieved.
Students will recognize that:
a. Similar scientific investigations seldom produce exactly the same results, which may differ due to unexpected differences in whatever is being investigated, unrecognized differences in the methods or circumstances of the investigation, or observational uncertainties.
b. Some scientific knowledge is very old and yet is still applicable today.

S5CS8. Students will understand important features of the process of scientific inquiry.
Students will apply the following to inquiry learning practices:
a. Scientific investigations may take many different forms, including observing what things are like or what is happening somewhere, collecting specimens for analysis, and doing experiments.
b. Clear and active communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world.
c. Scientists use technology to increase their power to observe things and to measure and compare things accurately.
d. Science involves many different kinds of work and engages men and women of all ages and backgrounds.

NGSS 2013

4-PS3-1. **Use evidence to construct an explanation relating the speed of an object to the energy of that object.** [*Assessment Boundary: Assessment does not include quantitative measures of changes in the speed of an object or on any precise or quantitative definition of energy.*

4-PS3-2. **Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

4-PS3-3. **Ask questions and predict outcomes about the changes in energy that occur when objects collide.** [Clarification Statement: Emphasis is on the change in the energy due to the change in speed, not on the forces, as objects interact.] [*Assessment Boundary: Assessment does not include quantitative measurements of energy.*]

4-PS3-4. **Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.*** [Clarification Statement: Examples of devices could include electric circuits that convert electrical energy into motion energy of a vehicle, light, or sound; and, a passive solar heater that converts light into heat. Examples of constraints could include the materials, cost, or time to design the device.] [*Assessment Boundary: Devices should be limited to those that convert motion energy to electric energy or use stored energy to cause motion or produce light or sound.*]

4-ESS3-1. **Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** [Clarification Statement: Examples of renewable energy resources could include wind energy, water behind dams, and sunlight; non-renewable energy resources are fossil fuels and fissile materials. Examples of environmental effects could include loss of habitat due to dams, loss of habitat due to surface mining, and air pollution from burning of fossil fuels.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Asking Questions and Defining Problems

Asking questions and defining problems in grades 3–5 builds on grades K–2 experiences and progresses to specifying qualitative relationships.

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. (4-PS3-3)

Planning and Carrying Out Investigations

Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

- Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)

Constructing Explanations and Designing Solutions

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1)
- Apply scientific ideas to solve design problems. (4-PS3-4)

Obtaining, Evaluating, and Communicating Information

Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods.

- Obtain and combine information from books and other reliable media to explain phenomena. (4-ESS3-1)

Disciplinary Core Ideas

PS3.A: Definitions of Energy

- The faster a given object is moving, the more energy it possesses. (4-PS3-1)
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)

PS3.B: Conservation of Energy and EnergyTransfer

- Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-2), (4-PS3-3)

- Light also transfers energy from place to place. (4-PS3-2)

- Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy. (4-PS3-2),(4-PS3-4)

PS3.C: Relationship Between Energy and Forces

- When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3- 3)

PS3.D: Energy in Chemical Processes and Everyday Life

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use. (4-PS3-4)

ESS3.A: Natural Resources

- Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. (4-ESS3-1)

ETS1.A: Defining Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.*(secondary to 4-PS3-4)*

Crosscutting Concepts

Energy and Matter

- Energy can be transferred in various ways and between objects. (4-PS3-1),(4-PS3-2),(4-PS3-3),(4-PS3-4)

Cause and Effect

- Cause and effect relationships are routinely identified and used to explain change. (4-ESS3-1)

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Connections to Engineering, Technology, and Applications of Science

Interdependence of Science, Engineering, and Technology

- Knowledge of relevant scientific concepts and research findings is important in engineering. (4-ESS3-1)

Influence of Engineering, Technology, and Science on Society and the Natural World

- Over time, people's needs and wants change, as do their demands for new and improved technologies. (4-ESS3-1)
- Engineers improve existing technologies or develop new ones. (4-PS3-4)

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Connections to Nature of Science

Science is a Human Endeavor

- Most scientists and engineers work in teams. (4-PS3-4)
- Science affects everyday life. (4-PS3-4)

Resource for Learning Sgaw-Karen:

Rev. David Gilmore, M.A. (1898) A Grammar of the Sgaw Karen. Rangoon: American Baptist Mission Press.

Week 1 September 4

Decontextualizing the Big Idea[1]of Science

Starter questions — What is science?

10-15 minutes — What are some big ideas of science? How are these ideas used?

What are some everyday ideas of science? (Pokemon, gardening)

How do we use these ideas?

Show "What is Science" ppt.

What is culture? Why is it important to science?

Placing the Big Idea in a Science Context

Science & Measurement — Scientists begin with a few basic tools. Language is a very important tool.

10 minutes — Scientists have to know the language of science. For example, how do we measure length? Historically, length was measured using the foot as the unit of measurement. A foot is 12 inches long. But now a meter is the most commonly used unit of measurement. You can see how confusing it would be if everyone used a different unit to measure length or distance.

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Designing an Experiment

20-30 minutes

Materials: Science notebooks (one for each student), pencils, markers or crayons

Take out your science notebooks and write your name on the inside.

Measure the length of the classroom using your foot as the unit of measurement. Count how many "feet" are in the length of the classroom

We will record all of the measurements on the board.

Calculate the mean (average), median (the middle) of the measurements.

What's wrong with this experiment? Why are all the numbers different?

Repeat the same measurement using metric sticks.

Record the data on the board and compare the highest, lowest, mean and median with the previous measurements.

[1] Quigley, C., Pongsanon, K. & Akerson, V. (2011) If we teach them, they can learn: Young students views of Nature of

Science during an informal science education program. *Journal of Science Teacher Education 22*, 129-149.

Assessing Prior Knowledge
5-10 minutes In our experiment, what is the more scientific unit of measurement? Why?

Do we all agree? Why is it important in science to be as accurate as possible?

Research Project Explain and hand out consent forms for research project.

Sgaw Karen language lesson
10-15 minutes

Week 2 September 11
An Introduction to Physics: Potential and Kinetic Energy
20-30 minutes I am going to show you three things. You tell me which one is the best example of the science of physics. (show the jack-in-the-box, water pouring into a bowl, a rubber ball bouncing) Show of hands. Post their arguments on the board.

You are all right! The jack in the box is an example of a simple machine. What simple machine does this depend upon? A spring! What are some other machines that use springs? (guns, bows, clocks) This is an example of **force.** For example, a rubber band is an example of a spring. **Energy** is stored in the band when you stretch it and released when you let go. Can you explain what **force** is in action in the toy?

The water pouring is also an example of **stored energy** being released. Does water contain **force**? What happens in a flood? If we were to pour this water down a dirt pile, would it have enough force to change the dirt, move it into a new shape? What about a dam? How is the moving water contained by a dam used to produce electricity? This is called **kinetic energy,** energy on the move.

Another example. Here is a rubber ball. What kind of **energy** does this ball hold? **Stored energy or potential energy.** Now, when I drop it, what kind of **energy** is released? **Kinetic energy.** That is the language of science.

Constructing a scientific explanation

Let's build an experiment. Here is our question: Can a small ball bounce higher if it bounces off a larger ball? So, for example, here is the large ball bouncing. You are going to measure that. Then here is the small ball bouncing. Measure that. And now bounce them both together, the small one on top. Measure how high the small ball bounces (using the meter stick, mark off one meter on the wall).

Does the small ball bounce higher? Why or why not? Record measurements on the board. (transfer of energy from the larger ball to the small ball).

What **claim** can we make based on this experiment? What **evidence** do we have to support this claim? Are there other arguments we can make based on our evidence?

Reflection How can we define **stored energy (potential energy) and kinetic energy** using our experiment with the balls?

Research project Introduce the Photovoice project. Talk about the use of cameras and privacy rules (only family members and public events; don't intrude on anyone's space).

Directive: Take photos of your understanding of culture and science. Bring the cameras back next week so we can develop the photos. Pass out cameras and use tape to write students' names on cameras.

Review of Sgaw Karen
10-15 minutes

Week 3 September 18 Physics: Force and Motion

10-20 minutes Review of potential and kinetic energy. Collect cameras from students.

Introduce a new Physics project: **The Force of Flight**
Show video on flight.
Prompt for reflection: How do planes fly?
Identify the 4 forces that make an airplane fly:

Four Forces Affect Things That Fly:

1. **Weight** is the force of gravity. It acts in a downward direction—toward the center of the Earth.
2. **Lift** is the force that acts at a right angle to the direction of motion through the air. Lift is created by differences in air pressure.
3. **Thrust** is the force that propels a flying machine in the direction of motion. Engines produce thrust.
4. **Drag** is the force that acts opposite to the direction of motion. Drag is caused by friction and differences in air pressure.

Howthingsfly.si.edu/forces-flight/four-forces
http://www.sciencekids.co.nz/videos/engineering/flightaerodynamics.html
http://www.boeing.com/Features/2011/03/bca_747-8_majestic_first_flight_03_21_11.html

Use a model airplane to illustrate how these forces work or use the video on above website.

Design your own paper airplanes. Pass out paper. Illustrate a basic model.
Have everyone fly their plane and measure the distance using the meter sticks.
Introduce the idea of the paper airplane contest for next week.
Questions to ponder: What affects the distance a plane can fly?
What happens when we add extra weight to our plane?
If there is time, add paper clips to the original airplanes to see if they fly further with extra weight.

Sgaw-Karen language lesson
10-20 minutes

Week 4 September 25 Physics: Force and Motion

Review: Weight, lift, drag, thrust
Review of the paper airplane contest, and materials available.

http://www.teachersdomain.org/resource/ess05.sci.ess.eiu.galileomoon/

http://www.pbslearningmedia.org/resource/phy03.sci.phys.energy.galileotele2/galileos-telescope/

Introduction to the **Moon Journal** project (28 days; need 14 pages in science notebook set aside). Show ppt. Show examples of illustrations. What are some data we can record? (sketch, date and time, weather conditions, position in sky relative to a landmark, appearance of the moon and any curious features) This is a long-term research project, to be conducted over the course of a month beginning October 1.
What is the question we are trying to answer? What are the phases of the moon?

Experiment Paper Airplane contest
Give students 15 minutes to construct their airplanes.
Use the hallway; mark out beginning point with tape; set rules for contest (can they run up to the mark and then throw it? How many tries does each person get?)
Mark each flight with a piece of duct tape and initials of student.
Use meter sticks to measure distances.
Record on board. Decide on winner. Why did this airplane fly the farthest?
Which of the **forces** of flight came into play? (weight, lift, drag, thrust)

Research project Make sure all of the cameras (labeled) have been turned in

Sgaw-Karen language lesson
10 – 15 minutes

Week 5 October 2 Physics: Sound Waves

4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. [Clarification

Statement: Examples of models could include diagrams, analogies, and physical models using wire to illustrate wavelength and amplitude of waves.] [*Assessment Boundary: Assessment does not include interference effects, electromagnetic waves, non-periodic waves, or quantitative models of amplitude and wavelength.*]

Sgaw-Karen lesson
10-15 minutes

Review of the Moon Project
http://www.biography.com/people/galileo-9305220

Review of Galileo and how his culture at the time affected his science
Review of data collected.

In a couple of weeks, we will have a storytelling session about the moon. Ask your family for cultural stories about the moon that you can share with the class. Or make up a story about the moon that brings in elements of your family history or culture.

Constructing a Scientific Explanation with Sound Waves

Watch drum videos on PBS:
http://www.pbslearningmedia.org/resource/phy03.sci.phys.mfe.zhanadrum/hanas-japanese-drums/
http://www.pbslearningmedia.org/resource/vtl07.la.rv.text.drums/ancestors-talk-through-drums/

Discuss the cultural significance of music: Why is it important to continue traditions? Who gives us cultural traditions?

Focus Question: How does sound travel?
Strike a drum and a guitar. How does the sound travel to your ears? (sound waves) Have you ever seen waves at the ocean? In a stream? What do waves look like? What causes waves? When we hit the drum or strum the guitar, the **force** disturbs the air around the instrument, causing sound waves. Sound waves carry **energy.**

Claim: Sound travels through waves of energy.
Cover your ears. Can you still hear the drum? Can sound waves travel through obstacles such as your hands? How do sound waves travel? Can they travel in outer space? Why or why not? Why are some sounds high and some sounds low?

Evidence: We can feel the vibrations of the energy being released from the drum. We can hear the sound of the drum and the guitar through our hands and through the wall so we know sound travels through air and some obstacles.

http://www.pbs.org/wnet/musicinstinct/education/lesson-plan-3-good-vibrations/media-resources/119/

Sound Waves and Amplitude

Pass out the slinkys. Once they have settled down, remind them about **stored energy and kinetic energy.** When we move the slinky, what kind of energy travels down the length of the slinky? (kinetic) Where does that energy come from? (your arm) Draw several waves on the board.

Another way to think about waves and how they carry energy is in terms of **amplitude.** A low energy wave (draw on board) has low **amplitude** (draw a line from top of wave to bottom) and a high energy wave has high amplitude (draw a high energy wave on board).

What would a low energy wave look like with your slinky?
What would a high energy wave look like?

What about when PSP sings a high note? What does that energy wave look like?
What about a low note? What does that energy wave look like?

Week 6 October 9, Physics: Waves

Sgaw-Karen lesson

http://www.pbslearningmedia.org/resource/kqed07.sci.ess.lpwaveenergy/origins-of-wave-energy/

Review: Sound waves are a form of energy.

Last week we looked at sound waves and the **frequency.** Who remembers how the frequency affects the sound of waves? (higher frequency, higher sound) Where do waves come from? (disturbance in air, water, etc)

Scientific Inquiry Now that we have an idea of what sound waves look like, can we speculate about what **medium** sound waves travel through to get to us?

Let's consider two scientific questions:

Can sound waves travel on the moon?

Can sound waves travel under water?

Show ppt with Pokemon character. Ask the students to draw a character that can emit sound waves either on the moon or under water. Each character should have 3 scientific characteristics that the students can explain to the class, 1 of which needs to be about sound (examples: particular kind of skin that absorbs sound; sound transmitted through touch or eye contact, etc.). Students can make these drawings in their scientific notebooks or on construction paper.

Gather the class to discuss their drawings in the large group after 10 minutes or so.

Experiment on sound waves

Materials: hangers, string, plastic cups

Cut different lengths of string for each group (2-3) of students. Attach one end of the string in the end of the cup and the other end on the hanger. One person holds the cup to their ear while the other person plucks the string.

Experiment with the sounds when the strings are plucked. Which sound is higher? When the string is short or long? Write your observations in your science notebook.

What have we learned about sound waves (that shorter strings have more tension and the waves are higher) Can we relate this to the strings of a guitar? Which strings make a higher sound? What about the drums? This comes from **frequency.** Draw different waves on the board.

Review of the Moon Project

In 2 weeks we will tell stories about the moon and after that we will build a project of the phases of the moon.

What phases have you drawn so far? Have you been able to draw the moon clearly every night? Why or why not?

Week 7 October 16, Photovoice Focus Group

Sgaw-Karen Language Lesson
10-15 minutes

Photovoice Exercise 1. Distribute all of the photos collected through the disposable cameras (all photos should be labelled with the student's name)

2. Ask each student participating to select 5 photos that best describe that student's understanding of himself/herself as a scientist acting within a culture.

3. Ask each student the following questions and record the answers:

a. What do you see in this photo?

b. Why is this photograph important to you?

c. What does this photograph say about your culture or your engagement with science?

Review of the Moon Journal Project

What data have students collected so far?

As we learn about the phases of the moon, what cultural questions can we ask?

Week 8 October 23 Earth and Space: Phases of the Moon

http://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.mphase/phases-of-the-moon/

Sharing myths about the moon

Share a couple of books written about the moon that tie in to children's cultural beliefs. Why is it important to honor our cultural beliefs? Why do so many people associate the moon with spirituality? What is the relationship between spirituality and science? Can we respect both at the same time? Even though we know most stories about the moon are not scientifically true, why are they important anyway?

Illustration

Rona, Maori legend of the moon
http://www.youtube.com/watch?v=2z5YhELaILk

Aboriginal legend of the moon
http://www.youtube.com/watch?v=C9BBZz9qSvE

African legend of the moon
http://www.youtube.com/watch?v=UWU2oyqCg5o

Writing stories about the moon

In the blank books provided, design and illustrate your own story about the moon, using your own cultural knowledge about your people, your family, and what they believe. If you don't know a cultural story about the moon, you can make one up as long as it illustrates something important about your culture.

Week 9 November 6 Earth and Space: Phases of the Moon

Sgaw-Karen lesson

Phases of the Moon Project

We have looked at scientific and cultural knowledge about the moon.
What are some scientific facts we know about the moon? (no air so no sound; no atmosphere so the sky always appears black; very little gravity)

Why does the moon appear in phases on different nights? What have you observed from your moon journals?

What is the difference between scientific knowledge and cultural knowledge? Does cultural knowledge have to be supported by evidence?

What do we know about how people have collected cultural knowledge that is centered around the moon? Spiritual meaning, cultural meaning of the moon. Read Rabbit and the Moon Man, a Cree story about the moon.

In the stories you have written, what are some of the cultural characteristics that you included? Any science facts?

Phases of the Moon Model

Materials needed for each team: 8 small Styrofoam balls, 1 med Styrofoam ball, 1 large Styrofoam ball, toothpicks, flat surface for base, flashlight, black marker

1. Stick a toothpick in the large Styrofoam ball and stick the other end of the toothpick in the base near one edge. This ball represents the sun.
2. Do the same for the medium ball and place it in the center of the base. This ball represents the Earth.
3. Using the marker, color exactly half of each of the small balls black. These will represent the different phases of the moon.
4. Draw a diagram on a piece of paper that shows the position of the Moon, Sun, and Earth during each of the following phases of the moon:

New, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, waning crescent

Have all of these phases illustrated on a chart for children to refer to.

5. Create a 3-D model of your diagram by using toothpicks to attach the Styrofoam moon balls to the base in their proper positions relative to the Earth and Sun. Imagine you were standing on the Earth ball and position all of the moon balls accordingly.
6. Darken the room and hold a flashlight next to your Sun to test your model. Move the balls as necessary so they are in the correct positions relative to the Earth and Sun. Label each phase on the base.

Reflection

What does our model tell us about the phases of the moon? Why does the moon appear in different stages of light and darkness at different times of the month? (because we are viewing the reflection of the light from the sun off the moon from our perspective on earth)

Time for work on the moon stories

Hubble Telescope Movie (5 min)

Week 10 November 13 The Energy of the Earth: Biomes

Sgaw-Karen lesson

Energy Quiz: Post-assessment

1. Give me 1 example of potential energy.
2. Give me 1 example of kinetic energy.
3. Name 2 of the 4 forces that affect airplanes (weight, lift, thrust, drag)
4. Who developed the telescope?
5. What else did this person invent/discover?
6. How does sound travel?
7. Sound waves are not a form of energy, true or false?

8. Name 2 media that sound waves **can** travel through?
9. What place has no sound? Why?
10. A low energy wave has (high/low) amplitude?
11. Amplitude is a measure of sound _____?
12. A sound wave with a high frequency projects a (high/low) sound?
13. Frequency is a measure of sound _____?
14. Name 3 phases of the moon.
15. The light that reaches the moon comes from the sun or the earth?
16. The moon rotates around the sun or the earth?
17. What is the name of the giant telescope that currently orbits the earth?

Introduction to Biome study: Temperate Forest

Show a snippet of the Living Planet movie: temperate forest

What is a biome? (desert, tropical rainforest and temperate forest, aqatic (freshwater and marine), grassland and tundra)

Start with the state of Georgia. What biome is Georgia in?
Climate indicators for the Georgia biome (Temperate Forest):
What kinds of plants do we have in Georgia?
What kind of seasons do we have in Georgia?
Do we have rainfall here? How much? As much as Ecuador?
What is the soil like?
What kinds of animals do we have in Georgia?
What kinds of animals can't live in Georgia?

In order to develop a complete socio-cultural ecological portfolio of Georgia, what criteria would we need to explore? (weather, climate, landscape, water sources, major cultural features, economy, animals, plants, etc) Place all of these criteria in sticky notes on the giant state.

Roll out the big world map and have students place a sticky note on the country they choose to work on. Next week we will have notebooks that you can fill with all of the information you gather on your biome and your country. Think of at least one socio-scientific question that you want to answer in this project. Examples of questions are below:

How has climate change affected the frog population in Central America?
What animals have become extinct in the tundra biome over the last 10 years and why?
What role does commercial development play in the shrinking coastline of Georgia?
What is the ecological function of caves?
What happens to Georgia if the polar ice caps melt over the next 20 years?
What do people in South America do to support their families?
How does the increase in air pollution across the globe affect Italy?
What is the carbon footprint of bottled water that travels from Fiji to the U.S.?

Time to finish books about the moon
Take time now to work on your moon stories or to look through these books to begin to gather information about your place study.

Week 11, November 20 The Energy of the Earth: Biomes

Sgaw-Karen lesson

What would Halloween be like without the Ecuadorian Rainforest?
(resource: http://www.rainforest-alliance.org/curriculum/fourth)

Do you know where chocolate comes from? Have you ever heard of a chocolate
Farm? Can you imagine living or working on a chocolate farm? How many of your families grow things at home? How many grow chocolate at home?

Show slide show of Chachi Cocoa Farmers:
http://www.rainforest-alliance.org/sites/default/files/site-documents/education/documents/ecuador-slideshow.pdf

Show chocolate slide show:
http://www.rainforest-alliance.org/sites/default/files/site-documents/education/documents/cocoa_slideshow.pdf

Locate Ecuador on the globe. How far is that from us? How many countries are in-between chocolate farmers and us? Why can't we grow cocoa here?

Biome project
Climate indicators for the Ecuador biome (Rainforest):
Let's look at what's happening in the rainforest today:
http://www.pbslearningmedia.org/resource/tdc02.sci.life.oate.rainforest/amazon-rainforest/
What people live in the rainforest?
Show Romel's rainforest home: http://www.rainforest-alliance.org/kids/stories

What kinds of plants does Romel have in Ecuador?
What kind of seasons?
How much rainfall?
What is the soil like?
Week 12, December 4 The Energy of the Earth: Biomes

Sgaw-Karen language lesson

Story of Stuff II: http://storyofstuff.org/movies/story-of-citizens-united-v-fec/

How has our passion for **stuff** affected our planet?
Now that we have looked at different climates on the planet, let's look at the big picture of climate change.
http://climate.nasa.gov/education/edResources/
http://climate.nasa.gov/climate_reel/TourCryosphere640360/
http://climate.nasa.gov/climate_reel/TemperaturePuzzle640360/
http://www.pbslearningmedia.org/resource/ess05.sci.ess.earthsys.esglaciers/earth-system-ice-and-global-warming/

Why are glaciers indicators of global climate change?

Week 15, January 8, 2015 The Energy of the Earth: Climate
Crazy Georgia Weather!

Sgaw-Karen language review

Opening question: What's going on with the crazy shifts in the weather?
Rain rain rain all weekend and temperatures of 50-60 degrees
15 degrees overnight last night

What do you know about weather? What affects the weather we have here in Georgia?

Atmosphere **99.998%**

Nitrogen	78.08%
Oxygen	20.95%
Argon	0.93%
CO2	0.033%

Plus water vapor
5 layers in the atmosphere; the one closest to the earth is **the troposphere**
This is where weather happens.

Hydrologic cycle evaporation
Transpiration
Condensation
Precipitation
Runoff (How is water stored on the earth? How does this become polluted?)

Heat energy What part of the earth absorbs the most heat energy on a consistent basis?

Jet streams www.srh.noaa.gov National Weather Service

Jet streams of air form around the borders between hot and cold air
Jet streams in the ocean: **El Nino** after Christmas (hurricane Igor in 2010)

Gulf stream in the Atlantic Ocean
California stream in the Pacific

Georgia weather **www.weather.com** winter forecast 2014-2015

Meteorologists attribute the craziness in our weather to a fluctuation in the jet
Stream

Scientific investigation All that rain we had last weekend: what happens to the water?

Pass out science notebooks.

Building an Aquifer Model (*Teaching Science in Elementary & Middle School, pp.176-177)*

Materials: 2-liter soda bottles; clay (I used kitty litter); gravel; topsoil; nylon; sand; pencils; eyedropper;
Science notebooks

Procedure: Cut the tops off the soda bottles and take off the labels. Layer the different earth substances in the bottom half of the bottles. How are the layers different? How are they the same? Draw a picture in your science notebook. (write "aquifer" on the white board) Identify the different layers that you have (sand, gravel, clay, topsoil) What is going to be a healthy amount of layers in the soil? What would be unhealthy?

Wrap the piece of nylon around the pencil and insert it into the soil layers to simulate a well. Go all the way through to the bottom layer. Slowly pour water in the area around the well and observe what happens. Record your observations in your science notebook. How does the water filter through the soil layers? Is this what happens to rain? What if we paved over the dirt with concrete? What happens to the rain then? (storm drains)

Take the pencil out and leave the nylon in. Extract water from the "well" with the dropper. Describe what happens to the water in the well.

Now add 10 drops of food coloring to the soil outside the well, simulating contaminants being added to the water supply. How does this happen in real life?

Continue drawing water from the well with the dropper. What happens? Record this in your science notebook (draw a picture). Does the pollution reach the bottom layers? How?

Where does our drinking water come from?

Reflection What sources of aquifer pollution have you observed around your community?

Is there any way to prevent our groundwater from being polluted?

Photovoice exercise

Label the cameras with students' names. Any new students will need to fill out permission forms for this exercise. Distribute the cameras with the prompt: Take photos of things in your life that make you think of science or culture.

Next week we will begin interviews again.

Week 16: January 15, 2015 Climate continued: Water Supply

Sgaw-Karen lesson

Collect cameras and distribute to new students.

Review Biome lesson: What biome is Georgia in? (temperate forest)

Review natural history work: Mary worked on Georgia

Show Water ppt. Refer to students' knowledge on rainforest biome: Thailand and Burma; and desert biome: Africa – Tyler
What climate do these countries have? How much rainfall?

Water cycle lesson cont Review stages of hydrologic cycle. Pass out science notebooks.
Walk outside on the school grounds to sketch out the landscape. We are looking for sources of water from each of the stages:

Transpiration
Precipitation
Condensation
Evaporation
Runoff

Take samples of water from anywhere you can find outside. We will test a water sample inside for iron, chlorine and nitrates.

Also, sketch the garden site and the surrounding landscape. Identify trees and birds/bugs that are in the area. How big is it? What is there now? Let's take a soil sample to see what nutrients are present.

Pass out baggies so students can bring in soil samples from home. Next week we will test the soil samples.