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Engaging Karen refugee students in science learning through a cross-cultural learning community

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ABSTRACT

This research explored how Karen (first-generation refugees from Burma) elementary students engaged with the Next Generation Science Standards (NGSS) practice of constructing scientific explanations based on evidence within the context of a cross-cultural learning community. In this action research, the researcher and a Karen parent served as co-teachers for fourth- and fifth-grade Karen and non-Karen students in a science and culture after-school programme in a public elementary school in the rural southeastern United States. Photovoice provided a critical platform for students to create their own cultural discourses for the learning community. The theoretical framework of critical pedagogy of place provided a way for the learning community to decolonise and re-inhabit the learning spaces with knowledge they co-constructed. Narrative analysis of video transcripts of the after-school programme, ethnographic interviews, and focus group discussions from Photovoice revealed a pattern of emerging agency by Karen students in the scientific practice of constructing scientific explanations based on evidence and in Karen language lessons. This evidence suggests that science learning embedded within a cross-cultural learning community can empower refugee students to construct their own hybrid cultural knowledge and leverage that knowledge to engage in a meaningful way with the epistemology of science.

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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. 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. Standardised 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 Next Generation Science Standards (NGSS) (Achieve, 2013) emphasis on performance through the use of science and engineering language and practices calls for students to adopt 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

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engage in these practices in a meaningful way. Many refugee families resettling in the U.S. have escaped 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 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 (Martin, Wassell, & Scantlebury, 2013).

In this research, I collaborated with Karen (first-generation refugees originating from Burma) parents to design and implement a cross-cultural science after-school programme for Karen and non-Karen fourth and fifth graders at a school in the rural southeastern U.S. In an ethnographic study that took place the previous summer, Karen parents identified what cultural and scientific knowledge they wished their children to retain as they integrated into education in resettlement (see Harper, 2015). Based on the results of this previous study, this research had two objectives: (1) to allow Karen parents to represent their own cultural knowledge in a public forum in a way that directly benefited their own community (the after-school programme at a public school) and (2) to explore whether or not Karen cultural knowledge could be leveraged to advance fourth- and fifth-grade Karen students in science learning. In the following paper, I look briefly at literature on refugee students and education in the U.S., discuss epistemological and theoretical frameworks for this study, and situate this research in science education literature on agency and student identity. 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 fourth and fifth graders?
(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 a science learning community?

Karen refugees and education

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 who originated in Karen State, Burma, lived in refugee camps on the Thai-Burma border for up to 20 years, without access to employment or higher education, before resettlement began in 2005. For Karen children, the transition process between educational systems during resettlement could be protracted and exacerbated by multiple moves. Kenny and Lockwood-Kenny (2011) determined that initial resettlement of Karen families in the U.S. most often resulted in a secondary migration based on existing ethnic and kinship networks. In their study of a Karen population in the northeast U.S., they found that children enrolled in a middle school that was listed as failing by No Child Left Behind did not have access to appropriate resources. Of the primarily Latino and African-American student population, Asian students made up less than 1%. Karen students were placed

in a Language Transition Support Services class with 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, researchers observed this enthusiasm quickly waned, and Karen students came to be seen as oddities in the school community. Many left school to begin factory work alongside their parents, and very few children stayed in school through the secondary level.

Studies on the academic success of refugee students, although extremely limited, suggest the development of outreach programmes to facilitate the integration of refugee parents into a school's community of practice is critical to the academic and social success of refugee children (Isik-Ercan, 2012; Kirova, 2012). One private agency in the southeastern U.S., Refugee Family Services (RFS), sponsored after-school tutoring, a summer camp, individual tutoring, at-risk services, English lessons for adults, job counselling, cultural information for the community and refugee families, and their centrepiece programme, a cultural liaison staff that bridged the cultural 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. 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 higher expectations for advanced education through college or vocational schools for their refugee students (McBrien & Ford, 2012). Research on the integration of refugee students into science learning is even more limited. Hammond's (2001) work with the Mien people contended that Mien scientific knowledge was embodied in their self-sufficient technologies. By employing a multi-science approach, she was able to incorporate indigenous science into Western science to create a 'dialogic learning community in which various voices were heard' (2001, p. 987).

De-settling the cultural terrain of science education

This research builds on science education literature that seeks to reconcile epistemologies of non-dominant populations with the use and production of knowledge in the mainstream science classroom. Scholars in equity and science education 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; Chinn, 2010). 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) modelled on diverse students' cultural literacies expanded the space for meaning-making in science. In their study with English, Haitian, and Hispanic third and fourth graders, Rosebery and colleagues designed lesson plans that brought students' experiential knowledge to bear on their co-construction of meaning in science learning. 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.

One paradigm of culturally sustaining science education that has allowed students' cultural literacies to create a more permeable learning environment in the classroom calls for the 'de-settling' of expectations and assumptions implicit within the dominant culture of mainstream science education in the U.S. (Bang, Warren, Rosebery, & Medin, 2013). At the core of this paradigm is the understanding that the cultural terrain for science learning in mainstream schools is based on a historically hegemonic nature-culture divide that structures how teachers and students appropriate knowledge of the natural world and the human cultural world. Within this traditional dominant construct, 'settled expectations of nature-culture relations' in science learning have perpetuated time-space ontologies rooted in racial hierarchies and the ideology of settler-colonialism that allowed one people to enslave another (Bang & Marin, 2015, p. 532). Therefore, paradigms of learning that seek to 'de-settle' the cultural terrain of science learning re-situate the use and production of knowledge within the embodied knowledge of indigenous communities whose ways of knowing are not constrained by the traditional nature-culture divide. In their work with Native American students, Bang and Marin structured science learning in a way that disrupted the erasure of an Indigenous historical presence in traditional map-making and reinstated cultural practices such as naming and reading the land as legitimate currency in science education. They argued that these 'pedagogical forms transformed the potential identities and forms of agency available to Indigenous youth' (2015, p. 536).

Agency and identity within science learning

In order to create a more permeable cultural terrain for Karen refugee students to engage with science learning, it was important to recognise and if possible dismantle social forces within our setting that anchored the dominant culture in place and provide a culturally sustainable way for Karen students to populate the space with meaning. Recent research on agency and identity in science education has used practice theory to examine how normative science identities emerge from the cultural production of meaning in mainstream classrooms (Carlone, 2012). In this approach, a student's learning identity takes shape from sociocultural forces at the structural levels of school and classroom acting upon groups and individuals, who in turn make choices and perform actions that affect the permeability or impermeability of the cultural terrain of their learning environment. The actions and choices of individuals and groups depend upon and are constrained by the parameters of the social structures within which they operate; likewise, structures bend and fold according to those actions imposed upon them by individuals and groups (Bourdieu, 1977; Carlone, Johnson, & Scott, 2015). Students' science learning identities reside somewhat at the juncture of classroom structure and individual agency. Research in science education has focused predominantly on individual agency without attention to how groups generate meaning that bears heavily on students' identity formation (Carlone, 2012). Therefore, it was important for this study to de-settle existing assumptions about student identity that might have been generated at the macro structural level and implemented at the group level in the classroom, so that space could be created for new group formation and generation of meaning from a culturally diverse perspective.

Often it is the teacher's embodied representation of sociocultural forces impacting the classroom structure that affects how normative student science learning identities are

shaped and performed (Carlone et al., 2015). For example, if culturally sustaining practices are not tenable in the classroom structure, students with diverse cultural experiences such as protracted displacement in a refugee camp may not have a voice, and could struggle to adapt to the classroom culture (Upadhyay, 2009). Therefore, a critical approach to understanding classroom structure was mandated to make visible classroom discourses and practices. Barton and Tan (2010) used the cultural anthropology construct of 'figured worlds' to examine the relationship of agency and community-based science learning identities for middle-school students from a critical perspective. Agency occurred at the intersection of identity and figured worlds: 'The value of figured worlds in understanding agency emerges in how they set up identity and positionality as situationally contingent and under constant transformation' (2010, p. 192). Within this construct, students were able to imagine themselves to be community science experts and assume a critical stance towards the generation and distribution of science knowledge. In order to de-settle the cultural terrain of our learning space and create a critical classroom structure in which Karen refugee students could have greater access to an agentic science learning identity, I used a critical pedagogy of place framework for this study.

Critical pedagogy of place

The rural elementary school where this study took place had a student enrolment of 391, 60% of whom received free or reduced lunch in the 2013–2014 school year, according to the National Center for Education Statistics (2015). Seventy-four percent of the student body was white, and 9.6% were listed as Asian/Pacific Islander. This study was designed to situate science learning within a cross-cultural learning community that privileged Karen cultural knowledge over that of the dominant culture. The non-Karen students who chose to participate in our afterschool program, promoted as a Culture and Science program to 4th and 5th grade students at the host elementary school, over all of the other options available represented the existing identity for high-performing science students for the purposes of this study. The afterschool program took place in a 5th grade science classroom that arguably represented the mainstream classroom structure for that school; in other words, the physical space harbored invisible assumptions of the resident classroom culture. Applying critical pedagogy of place allowed us to challenge these assumptions by creating our own figured world within reconstituted space. Therefore, this research acted as a wedge in the foundation of classroom structure, creating a crack that in the end was not sustainable (Carlone et al., 2015). It contributes to the above literature in equity and science education for indigenous and culturally diverse students by exploring the potential for refugee students to develop agency and science learning identities within the tension of an unexpected crack in classroom structure.

Critical pedagogy of place ties the threads of place-based education, critical pedagogy, and an agenda for ecological sustainability into a versatile tool that addresses the undercurrents of power and domination amongst diverse human communities, and between social and ecological systems (Gruenewald, 2003). Critical pedagogy situates learning within the democratic process of problem-posing and teacher-facilitated dialogue (Freire, 1970). Students are free to learn about the problems that affect their communities and engage in praxis to effect social change. Therefore, a learning environment becomes a place to challenge existing knowledge and problematise the political, socio-economic

structures that perpetuate that knowledge (Kincheloe, McLaren, & Steinberg, 2012). Within this framework, 'place' has evolved from a bordered knowable entity into a critical construct that reflects the hybridity and fluidity of transient populations and their cultural knowledge (McInerney, Smyth, & Down, 2011). Situating this research within the concept of *place* recognised the inextricable relationship of involuntarily displaced people to the physical place where they live, work, and raise their children. *Place* in a globalised world of displaced peoples becomes socially constructed around communities, activities, and the meaning that binds people and activities together. It 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. In this respect, 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. 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.

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, & Barton, 2013). Place-based education has been referred to as embodied learning, a counter-narrative to homogenised education that can be dehumanising for children caught outside the mainstream. It shifts the paradigm of learning away from the institutionalised construct of school learning manifested by decontextualised knowledge, and situates it within the students' own cultural and experiential spaces (McInerney et al., 2011). In this way, education becomes a medium for individual and social transformation through the process of critical consciousness (Freire, 1970). Tan, Barton, Turner, and Gutiérrez (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' (2012, p. 40). From this position, they argued that learning is inextricably tied to students' self-knowledge and their construction of self-identity in science:

> 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. (2012, p. 41)

In this study, 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 porous.

Two objectives for education characterise this framework: decolonisation and re-inhabitation. Physical and cultural decolonisation of the learning space used in this research disrupted the normative classroom structure and any assumptions that science knowledge could only be produced and used by participants of the dominant culture. Decolonisation of our learning space occurred in four ways: (1) we decolonised the physical space of science learning by disrupting the established protocol of students seated at desks facing the teacher at the whiteboard; instead, teachers and students sat on a woven mat

on the floor in a circle; (2) we decolonised the cultural space of science learning through a Photovoice exercise that allowed students to create their own cultural discourses; (3) we decolonised science learning by prefacing science investigations with a Karen language lesson and by employing scientific practices that allowed students to act as producers of scientific knowledge; and (4) a Karen parent acted as co-teacher for the programme. 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. As a learning community we tried to re-inhabit our learning space with self-generated and legitimated knowledge based on participants' interaction with science investigations and each other.

Theoretically, emerging agency served as a marker for the how students negotiated science learning identities within the cross-cultural learning community (Freire, 1970). For refugee students, issues of 'belonging' can hinge on the identities and discourses they are able to access during the process of integration into traditional settings such as the local school (Strang & Ager, 2010). The power to use discourse to shape one's own identity or to have a hand in how a group identifies another 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 the interaction of teachers and administrators creating and perpetuating the classroom culture can reflect a homogenisation of cultural knowledge that excludes students who are considered 'other' by the dominant cultural group. A critical pedagogy of place framework afforded me the opportunity to focus on how refugee students positioned themselves in science learning within the reconstituted space of a cross-cultural learning community. The Karen co-teacher, students, and I were able to interrogate the physical and cultural spaces for science learning with attention to how students transformed, or re-inhabited, those spaces with self-generated discourses and knowledge.

Action research with a Karen community

Action research provided an emancipatory approach to learning, creating space for participants to act as agents with decision-making power in the production of knowledge (Reason & Bradbury, 2008). A Karen parent, Mary, and I served as co-teachers for the culture and science after-school programme. Mary's presence as co-teacher in the after-school programme was intended to represent Karen embodied knowledge. Since my own cultural background mirrored that of teachers and school administrators representing the dominant culture at the school, it was important to have Mary present in an active role. By teaching the Karen language, she gained status within the learning community as a holder of expert knowledge, and the language itself was presented as a legitimate literacy.

As part of an ethnographic study I conducted with Karen parents in the summer of 2013, I participated in Karen community events, visited the community garden, and attended the Karen church, over two years preceding the current study. When my research with Karen elementary students began the Fall of 2014, many Karen families in the rural community knew me through my relationship with Mary and her family, who served as translators and collaborators for the after-school programme. Six Karen students and

three non-Karen fourth and fifth graders participated in the after-school programme from September 2014 through January 2015. Karen students were recruited through home visits by myself and Mary over a series of Saturdays in which we met with parents to explain the programme in detail and read through consent forms together. Non-Karen students were recruited by means of a flyer distributed to students who participated in an after-school programme on-site at the school.

Constructing scientific explanations based on evidence

Academically, decolonisation 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 within a community of learning. The science learning discourse for the community was set in part by the curriculum we designed. Science investigations linked science learning with the critical significance of place and voice for culturally diverse students (Buxton & Provenzo, 2011). In accordance with NGSS and the Georgia Performance Standards for Science, we prioritised the following student outcomes in curriculum development: appreciating the diverse ways in which scientists conduct their work; understanding the power of observations; knowledge of and ability to ask testable questions and construct hypotheses; using various forms of data to search for patterns, and confirm or reject hypotheses; constructing and defending a model or argument; considering alternative explanations, and gaining an understanding of the tentativeness of science, including the human aspects of science, such as subjectivity and the sociocultural context of practicing scientists (Crawford, 2007). This approach allowed us to construct scientific knowledge together as a learning community by developing testable questions from our observations and everyday knowledge, and constructing scientific explanations based on evidence we gathered from our investigations. Students worked in pairs or small groups to collect data or build models, and then presented their work to the community. Any student could challenge another's claim if they had evidence to support their argument (Zembal-Saul, McNeill, & Hershberger, 2013).

Embedding scientific investigations within diverse cultural knowledge broadened the cultural terrain for our learning community. For example, in the series of lessons on the phases of the moon, we introduced cultural knowledge about the moon by reading children's books: *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. In addition, lessons were modified weekly to incorporate students' cultural and experiential knowledge as this became apparent within the community. Although students recognised that cultural knowledge was not equivalent to scientific knowledge, both were seen as important to our understanding of the moon.

Photovoice

An action research design allowed participants to articulate their own cultural identities through methods that fostered self-representation (Lykes & Mallona, 2008). Photovoice, a method used predominantly in public health research, allowed students and teachers

to construct a reciprocal relationship through shared storytelling that served as the foundation for the cross-cultural learning community (Wang, 2006). Participants were given disposable digital cameras the second week we met; each student practiced with a sample camera. I gave students the following prompt: *Take photos of your culture and science at home*. We defined culture as games that you play, activities and people that you value, and things that characterised your home life. We did not define the meaning of 'science' in their home lives but left that open for their own interpretation. Two weeks later, we held a focus group discussion in which their photos served as the prompt. The following questions were asked in the focus group:

(1) Pick out your favourite photo. What do you see? Why is this one your favourite?
(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?

Each person contributed to the discussion as we went around the circle three times. In order to deepen my understanding of how each student viewed his/her own culture and the culture of other students in the circle, I designed a game in which students closed their eyes and picked a photo from a pile in the middle of the circle. The student would hold up the photo for other students to identify something cultural or scientific in the photo. The purpose of the game was to challenge each of the students to recognise cultural and scientific characteristics from different cultural perspectives, either that of a Karen or non-Karen student. Students then selected five of their own photos to develop into a visual narrative which became the base for the narrative portraits (see figures 1–3) we teachers developed at the end of the programme. In this way, students participated in the storied cultural narrative of the learning community by contributing their own embodied knowledge of culture and science. Students took these visual narratives home once the teachers photographed them.

Video recordings of the after-school programme, including portions of the Photovoice focus group discussion, and ethnographic interviews with students (Spradley, 1979) at the beginning and end of the programme comprised the majority of data collected. Initial interviews of individual students were conducted during the first few weeks of the programme and focused on students' existing scientific and cultural knowledge. Interview questions with Karen students probed for memories they may have retained of the natural environment in Burma or Thailand. Closing interviews at the end of the semester were conducted with students informally in small groups. In addition to interviews, I collected my own reflections as a teacher/researcher in a journal, recorded field notes from community events with Karen and non-Karen students, and looked at visual and written narratives produced by students.

Data analysis with narrative portraits

With a small study population (nine students, two teachers), the majority of whom were English language learners, narrative analysis of qualitative data yielded patterns of how individual student identities were enacted within the cross-cultural learning community (Riessman, 2008). Data from the interview transcripts, participant observation field notes, transcribed videotapes of the after-school sessions, my reflective journal, and the

Photovoice focus group discussion were analysed deductively first to identify distinct discourses of cultural knowledge valued by this science learning community. Second, my Karen co-teacher and I reviewed the results of this data analysis to check my interpretation of discourses and interaction in the learning community. Then I analysed the data inductively, using agency as an indicator of change in how students positioned themselves socially and academically within the learning community. Social position was defined by the students' interaction with other students and teachers within the learning community; academic position was defined by the students' actions and words within the context of the language and science lessons.

Visual narratives produced through the Photovoice exercise were woven into narrative portraits (Lawrence-Lightfoot & Davis, 1997) to produce a 'quilt' of multi-layer meaning emerging from multiple voices. Narrative portraits provided a way to humanise participants who may have been objectified by dominant discourses, find points of connection and commonality, and weave them into the fabric of the learning community (Chapman, 2007). For the cross-cultural learning community, narrative portraits functioned as a means of reflective analysis. By reflecting on the reciprocal relationships of the learning community, the knowledge co-constructed there by students and teachers, and the way students represented their home knowledge in the photo narratives, we teachers tried to compose a written narrative that attempted to capture the storied narrative of our learning. The co-teacher and I designed narrative portraits for all of the student participants using the visual narratives developed by students during Photovoice, transcripts from videotapes of the after-school programme, ethnographic interviews, participant observation at community events, my teacher's journal, and our reflections together at the end of each session. In this way, Karen students were situated within narratives of resilience and community strength that reflected how the Karen people saw themselves in resettlement (see Harper, 2015). I was careful to situate myself within the narratives that I co-constructed with the participants. By serving as a teacher in the after-school programme and as a participant in the narrative portraits I used for data analysis, I chose not to isolate myself from my participants' activities or any interpretation of the activities.

Findings

Two patterns of student cultural and science learning identity formation emerged from narrative analysis:

(1) Karen students leveraged Karen cultural knowledge to become producers of legitimate cultural discourses within the learning community.
(2) Karen students leveraged family knowledge of the Karen language to engage in scientific inquiry within the cross-cultural learning community with a higher level of agency by the end of the programme.

Adopting varying discourses at different times, student participants moved in and out of individual science learning identities and group social identities. Within the learning community, the Karen culture was made legible in three primary ways: (1) through the Photovoice exercise; (2) through the Karen language lessons; and (3) through the presence of

Mary, the Karen teacher. At the beginning of the programme, non-Karen students demonstrated greater confidence in science learning than the Karen students did and often positioned themselves as small group leaders. This was evident in the Photovoice session in which Karen students were hesitant to identify artefacts of science in their home environments. In response to the prompt for a science photo, one of the Karen students held up a photo of a deer skeleton, but was unable to say why the skeleton represented science to him. 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 Karen 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. (journal excerpt, 16 October)

However, after four months, some Karen students began to demonstrate emerging agency in constructing scientific and cultural discourses for the community. Any change in social or academic positioning over time was flagged as a possible indicator of emerging agency which could lead to insight as to how students negotiated their position within the group and the cultural knowledge they leveraged to do so. In this section, I describe how three Karen students accessed discourses within the community to construct knowledge and legitimate it, and how these participants leveraged that knowledge to shift his/her standing within the group and gain agency.

Lucy

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, the group attempted to construct models of the phases of the moon. For the project, I handed out one-dimensional illustrations of the different phases of the moon so 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.

The small group of two Karen girls, Lucy and Hannah, and one non-Karen girl, Sally, developed tension from the start. Sally, a student with a high level of confidence in science learning, had an expectation of academic leadership. The following excerpt is taken from a videotape of students' presentations of moon models.

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 towards 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 (figure 1), she was adamant that her interpretation of the phases of the moon model was correct. Sally was equally as adamant. Each student was asked to construct her model for the group, and explain her reasoning behind the model. The group could challenge the reasoning behind either model, which they did. Although Lucy appeared anxious that her model might not be correct, she presented her model and her reasoning with determination. Other students within the community supported her reasoning, giving credibility to her role as an academic leader within the learning community.

Figure 1. Narrative portrait of Lucy and Hannah.

James

James selected a photo of the Karen flag as his favourite photo during the Photovoice focus group discussion (Figure 2):

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

Even though James entered the learning community as a social leader for Karen students, he was reluctant to expand on his knowledge of the flag during this Photovoice exercise at the beginning of the programme. 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. Later in the same Photovoice session, James expanded on his experience in Thailand:

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?

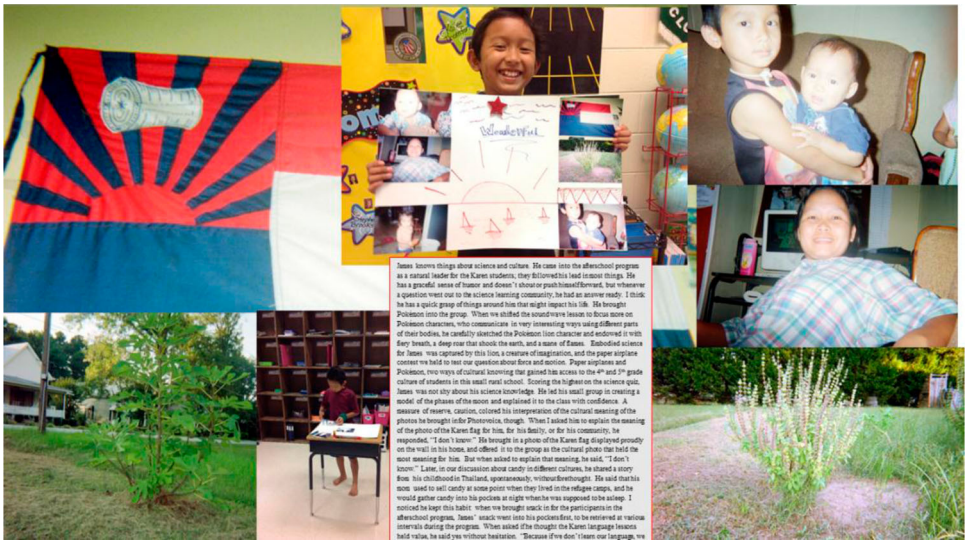

Figure 2. Narrative portrait of James.

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.

Tommy and Sally, non-Karen students, gave confident explanations when displaying photos and talking about their cultural experiences. Sally had travelled several times to Guatemala on mission trips and spoke with authority about the culture there.

In an example of how Karen students used a mix of cultural knowledge to shape hybrid cultural identities within the learning community and increase their standing within the group, James assumed a dual social and academic leadership role when we incorporated Pokémon into our lesson on sound waves. James and two other Karen boys had 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 fish could communicate under water. Students were asked to design their own imaginary creatures with three scientific characteristics, one of which had to be a means of transmitting sound waves:

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.

This exercise allowed students to draw from their peer cultural knowledge (Pokémon was popular with fourth- and fifth-grade boys), knowledge retained from their lives in Thailand, and their imaginations to construct scientific knowledge together as a learning community. In addition, students used this knowledge to access a more complicated scientific understanding about sound waves (one of the imaginary creatures lived on the moon, and students recognised that sound waves could not travel without a medium such as air or water) and then refined this knowledge within the group.

Lily

Another Karen student, Lily, positioned herself as a holder of expert cultural knowledge in the Karen language lessons (figure 3). Structuring the Karen language lesson into the curriculum for 15 minutes of every session of the after-school programme gave the Karen culture

Figure 3. Narrative portrait of Lily.

academic credibility as well as legibility. Karen and non-Karen students accessed the Karen language as a literacy in the same way that they accessed the language of science in science learning, through the cross-cultural learning community. The Karen language was new to all of the students; most of the Karen students had not learned Sgaw-Karen as a written language. However, we as a learning community recognised the value of learning the language of the Karen culture in the same way we recognised the value of learning the language of science. It gave the culture visibility and legitimacy as knowledge. The role of Mary, the Karen language teacher, was critical to the development of embodied knowledge for Lily and other Karen students. Although Mary began the after-school programme by instructing students in a didactic style, by the end of the semester she had shifted her instructional style to one that was more participatory. A video recording of a language lesson from the beginning of the programme shows Mary 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. A digital recording from later in the semester shows Mary crowded by the Karen girls up at the whiteboard.

By the end of four months, Lily was writing the words on the whiteboard and reciting the correct answers if other students struggled to respond. She positioned herself next to Mary with the marker in her hand poised to teach the Karen language lesson, assuming the role of a co-teacher. None of the other students positioned themselves in this way. In Lily's closing interview, in response to the question about which cultural activities in the programme 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 move into a leadership position in the science investigations, she engaged with science learning with higher academic confidence by the end of the semester.

When she participated in the moon modelling 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. She leveraged her expert knowledge of the Karen language to position herself within the science culture as a stakeholder rather than as a passive observer.

Discussion

Critical 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 decolonisation and re-inhabitation both within the traditional structure of a classroom and within an institutionalised understanding of scientific knowledge positioned the Karen co-teacher and the Karen student participants as stakeholders in science learning. 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. The re-inhabitation of classroom space took place through the construction of Karen and non-Karen cultural discourses and scientific knowledge simultaneously within the context of a cross-cultural learning community. Teachers and students re-inhabited this space with embodied science knowledge embedded within the framework of students' experiential and cultural knowledge. This involved a process of de-settling expectations for science knowledge, namely that scientific knowledge can emerge only from White teachers and scholars. Instead, this project opened the door to indigenous knowledge rooted in the present and past narratives of 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 porous.

Evidence of emerging agency for Karen students suggests that situating the construction of scientific knowledge within Karen cultural knowledge enabled Karen students to recognise the value of their culture to the larger discourse of science inquiry. By weaving cultural knowledge into science inquiry narratives about the moon and sound waves, Karen and non-Karen 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 environment that enlivened science learning for participants.

Implications for science teaching and learning

This research situated a pedagogical model of inquiry-based science education within a cross-cultural learning community in which students and teachers accessed multiple epistemologies to make sense of science and culture. Emerging agency by Karen students from first-generation refugee families suggests that embedding science learning within legible Karen cultural knowledge empowered some Karen students to position themselves as

stakeholders in science learning and holders of expert knowledge. This research builds on the work done by Chèche Konnen scholars (2010, 2013) to challenge the institutionalised science-culture divide present in school science and the pathology of powerlessness endemic within that divide for culturally diverse students. In turn, this research has opened space for a new meaning-making discourse that connects the streams of indigenous knowledge embodied by refugee students and teachers with the epistemology of science.

In this research, an understanding of the use and production of scientific knowledge emerged from a learning terrain in which contextually authentic science learning was 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 epistemology of Karen students and the Karen teacher was privileged within the physical and political spaces of the after-school programme. In this way, the assumption that the culture of science exists only within institutionalised ways of knowing was challenged. Multiple epistemologies emerging from diverse places and understandings were applied to the construction of scientific knowledge within the cross-cultural learning community. For Karen students in particular, the scientific practice of constructing explanations based on evidence gathered in science investigations proved to be a key characteristic of re-inhabiting their learning space. 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.

Finally, for science educators and teacher educators, this research contributed to an understanding of how group formation and meaning generation within a decolonised and reconstituted learning space could impact the science learning identity of Karen refugee students. In after-school programmes, Saturday science programmes, and cultural immersion programmes, teachers engaged in science inquiry with culturally rich students and their families through the shared learning objectives of a community of practice seem to be able to crack the crusty outer layer of school culture to allow students access to multiple epistemologies as they engage with the epistemology of science. In our after-school programme, Karen and non-Karen students accepted Karen knowledge as legitimate and appropriate within a science classroom rather than 'other'. The construction of hybrid cultural knowledge and scientific knowledge within the context of a cross-cultural learning community allowed more complex meaning to emerge than would have been possible in a traditional science classroom. As a result, Karen students acted as stakeholders in science inquiry, challenging the scientific reasoning of non-Karen students, and claiming the right to argue their own reasoning. This enacted learning identity suggests a more complex understanding of scientific knowledge, one that begins to embrace the epistemology of science.

Disclosure statement

No potential conflict of interest was reported by the author.

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