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Taking an active stance: How urban elementary students connect sociocultural experiences in learning science

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ABSTRACT
In this interpretive case study, we draw from sociocultural theory of learning and culturally relevant pedagogy to understand how urban students from nondominant groups leverage their sociocultural experiences. These experiences allow them to gain an empowering voice in influencing science content and activities and to work towards self-determining the sciences that are personally meaningful. Furthermore, tying sociocultural experiences with science learning helps generate sociopolitical awareness among students. We collected interview and observation data in an urban elementary classroom over one academic year to understand the value of urban students' sociocultural experiences in learning science and choosing science activities.

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Urban students can gain both voice and empowering science learning experiences. Science classrooms provide space that enables bringing together their past and current sociocultural experiences. Urban students not only want to learn science, but they also want to influence science content and related science activities that connect to their sociocultural experiences, languages, economic realities such as the mortgage crises, and racial diversity. Students can actively utilize these rich sources of knowledge in science classrooms and proceed to frame science learning through these experiences. Yet, many urban elementary students learn science ideas and topics decontextualized from their abundant sociocultural and sociohistorical experiences rendering science learning less meaningful and less connected (e.g. Buxton, 2010; Emdin, 2016; Ladson-Billings, 2014; Paris & Alim, 2014; Rodriguez, 2013).

Works in science education have shown that science is learned in a context and students make decisions about how, where, and when science knowledge is useful to them based on their rich sociocultural knowledge and experiences (Fleming et al. 2015; Paris & Alim, 2014; Seiler, 2001). When students draw from each other's varied and rich sociocultural knowledge, their understanding of science and the retention of science knowledge improves (e.g. Shady, 2014). Many studies have explored the intersections between urban science education and students' social, cultural, gendered, racial, and economic experiences; however, how students intentionally bring these experiences into science learning

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and gain voice, how they influence their teacher's pedagogical decisions, and how they build sociopolitical awareness is not fully explored.

In this paper, we specifically explore how fifth-grade students utilized their recent sociocultural experiences and home context in influencing their teacher's decisions about science activities and science content. We specifically draw from two theories, a sociocultural approach to learning as proposed by Gutiérrez and Rogoff (2003) and Rogoff (2003), and culturally relevant pedagogy (CRP) as proposed by Ladson-Billings (1995a, 1995b, 2001, 2006, 2014). We use sociocultural theory to guide and situate the ideas and assumptions about how students from diverse cultural groups best learn science, and we use CRP to examine and make sense of how students find science learning culturally meaningful and empowering. Both theories allowed us to better understand how students employed cultural capital, cultural elements, and other recognizable knowledge to learn meaningful science content and to use science for broader sociopolitical awareness. We discuss and contextualize sociocultural theory of learning and CRP in science teaching and learning in the works of science education scholars who have focused on the issues of science teaching and learning in urban school contexts with students from nondominant and immigrant groups (e.g. Aikenhead, 2001; Aikenhead & Jegede, 1999; Upadhyay, 2012; Lee & Buxton, 2011; Pierotti, 2011).

In this paper, we first provide a brief and relevant literature review on sociocultural theory of learning and CRP situating them within the literature of urban science education. Second, we describe the rationale for the qualitative methodology and data collection and analysis processes. Third, we present three findings based on our analysis. Finally, we discuss the findings and their implications situating them both in the urban science education literature and the larger literature of urban education.

Students accessing rich sociocultural differences for learning

A sociocultural approach to learning (Gutiérrez & Rogoff, 2003) emphasizes that culture is a dynamic and continuously evolving aspect of human experience (Gutiérrez, 2002; Rogoff, 2003). The culture of an individual evolves as she or he participates in new activities, encounters new economic realities, and participates in new relationships. Students who attend schools bring culture comprising their current everyday experiences and the history of the group to which they belong.

For example, a Hmong student's culture will be a mixture of historically gained values, such as learning as a group-based social activity where knowledge is passed on by the respected and wise elders to the younger generation of learners and listeners, as well as a more recent experience in U.S. schools where individual choice, individual learning, and use of personalized technology are more valued and rewarded. Therefore, Hmong students' culture of learning will be different from the culture of their elders making science learning a combination of group works and individual activities. In this and many other cases, recognizing students' evolving and shifting culture would improve learning science in many urban school settings. There is a need to view culture as the experiences of individuals as they are influenced by participatory activities, rather than passive traits (Paris & Alim, 2014; Gutiérrez, 2002) based only on their membership to a racial or ethnic group.

In science classrooms, students engage in learning science by participating in many different activities using known, new, and hybrid skills and contexts. During these activities, students are learning science through relationships and experiences gained from personal, local, and global interactions. If students are to become aware of the personal benefits of science, then science lessons and activities must connect to their experiences at home. For example, in a study by Upadhyay and his team (Upadhyay & DeFranco, 2008) students in a fifth-grade class were learning about the usefulness of the flu vaccine in preventing flu. Hmong students talked about the dilemma of convincing their family members – the elders – to get the flu vaccine. The Hmong belief that 'intentionally making a cut or piercing one's body is harmful because good spirit escapes the body and bad spirit can enter the body' (Upadhyay, 2009, p. 221) makes the fifth-graders task all the more difficult. Hmong students needed to blend a strongly held Hmong belief with their new scientific knowledge about mutation of the flu virus. Hmong students also needed to convince their elders that the flu vaccine protects all from sickness and that, just as there are different kinds of bad spirits, different kinds of sickness cause the flu. They used their knowledge of Hmong beliefs (static Hmong culture which gets passed from over generations without any change) and their scientific knowledge about mutation (new science culture for these students) to understand science, make sense of science learning, and bring that knowledge in a hybrid form to their homes for a better life.

The above example illustrates that as students engage in a science task, they are also engaging in many other practices across different tasks, skills, and sociocultural boundaries (Rosebery & Hudicourt-Barnes, 2006) where older and new sociocultural experiences are getting mixed and giving students new ways to engage with and in science. This leads us to think about learning as a complex sociocultural activity that utilizes the skills, practices, and tools of nondominant students, which then makes learning meaningful (Giroux, 1992; Gutiérrez, 2002; Paris & Alim, 2014).

Yet, the problem for many students from nondominant groups is that they find school science curricula, instructional practices, and school science culture to be rigid, predetermined, and exclusionary of their values and experiences (Calabrese Barton & Yang, 2000; Shanahan & Nieswandt, 2011). The perception of teachers and the culture of school science reinforce in students from nondominant groups that science is for intelligent, hardworking, and well-behaved students. For example, Calabrese Barton and Tan's (2010) study in an urban after-school Get City programme showed that when students from nondominant groups who struggled in school science were given opportunities to authentically participate in a setting that connected science to their lives, they successfully and strategically defined and consumed science as both creators and critical examiners of their science products. Therefore, we argue that the sociocultural differences that students bring to science discourses should not be sidelined, but celebrated and cherished as important and valuable knowledge and practices that support science learning.

The importance of the sociocultural theory of learning is central to understanding how urban students interact in science activities and discourses in the class, as well as how they contextualize science based on their life experiences at home, outside of the home. As urban classrooms are full of diverse and rich cultural knowledge and experiences, sociocultural theory further provides an appropriate lens to understand what, how, and why urban students want to learn in science. Therefore, this theory allows us to explore how fifth-grade students utilized their recent sociocultural experiences and home context in influencing their teacher's decisions about science activities and science contents and what they wanted to learn in science.

Students gaining voice through CRP

We draw from Ladson-Billings (1995a) original idea of CRP and her new addition to it as a 'remix' (Ladson-Billings, 2014). Ladson-Billings (2014) argues that the notion of culture in CRP needs to acknowledge that students' cultural experiences are fluid and changing and 'the Remix' (p. 75) reflects the fluidity of students' cultural experiences. She further argues that failing to recognize the fluidity of youth's cultural experiences will make learning even more decontextualized for nondominant groups. Therefore, new cultural experiences have to be connected to science contents and activities to make science learning meaningful. The CRP provides us another lens through which to view students. When they can infuse their sociocultural experiences during learning, they then acquire the ability to gain voice through empowering experiences and sociopolitical awareness in the science classroom. The theory relies on incorporating sociocultural experiences of nondominant groups in learning science and valuing those experiences, cultural knowledge and habits in classroom discourses (Ladson-Billings, 1995a, 1995b, 2001, 2014). An important goal of CRP is that it works to empower students from nondominant groups 'intellectually, socially, emotionally, and politically by using cultural referents to gain knowledge, skills, and attitudes' (Ladson-Billings, 2001, pp. 17–18). Ladson-Billings (1995b) asserted that learning science contents should build urban students' capacity to 'recognize, understand, and critique current social inequities' (p. 476).

Another important aspect of CRP is to encourage students to 'remix' their varied sociocultural experiences such as hip-hop, mortgage crises, Twitter®, YouTube®, etc., along with other home experiences, with the content they are learning and the classroom activities in which they are engaged (Ladson-Billings, 2014). This clearly indicates that the theory of CRP values students' evolving sociocultural experiences in learning science. Urban science classrooms need to encourage students to draw larger connections between science and their personal, local, and global perspectives. Ladson-Billings (2014) agrees with Paris (2012) that CRP has to include global experiences of students because they can then bring much wider sociocultural experiences in science learning. Students not only learn science contents but they also build a capacity to 'understand and critique their [social, cultural, and economic] positions and contexts … ' (Ladson-Billings, 2006, p. 37) as they learn science and participate in various science activities in a science classroom. We also believe that since CRP is oriented more towards social justice, advocacy, and equity ideas, it clearly creates opportunities for students from nondominant groups to critically explore what science content they learn and why they learn this content. Consequently, CRP allows students to extend the value of science learning beyond classroom experiences and into the homes and global experiences of their peers (Butler, Atwater & Russell, 2014; Rodriguez, 2013; Zipin, 2009). CRP provides opportunities to students to engage in science learning in their native languages (McKinley, 2005) and to utilize cultural tools from their native sociocultural experiences (Aikenhead, 2001; Taconis & Kessels, 2009). When students realize their personal sociocultural experiences matter in learning science, they can, through self-determination of which science contents are 'most meaningful to them', feel empowered (Ladson-Billings, 1995a, p. 160).

To this end, many research studies in science teaching and learning have shown that CRP not only improves academic achievement but also builds skills that aid students to critically examine the usefulness of science learned at school (e.g. Rosebery, Warren, Ballenger, & Ogonowski, 2005; Warren & Rosebery, 2008). One reason for increased student participation in out of classroom settings such as school gardens or community programmes is that these settings create a space where students have a greater potential to connect their formal science knowledge with their knowledge from home experiences or experiences that have profoundly influenced their family lives (Upadhyay, 2010; Hammond, 2001). Informal settings such as school gardens strengthen students' social and cultural values and knowledge with science and build respect for others' values and knowledge in discovering connections between science and social, cultural, economic, health, and other home experiences. In this way, useful knowledge is co-created, both for immediate use and for students' future lives. In a study of Haitian students, Warren and Rosebery (2008) found that students used 'everyday experiences to generate questions, possible explanations, new perspectives, and insights into the scientific phenomena they encountered in school' (p. 41). Nevertheless, in many urban science learning contexts, students who are not offered enough opportunities to incorporate sociocultural experiences feel less empowered to influence their learning and science activities.

Therefore, CRP as a theoretical lens, with the new 'remix', helps us understand the importance of students' evolving sociocultural experiences. We comprehend how fifth-grade students utilized their recent sociocultural experiences and home context to influence their teacher's decisions about science activities and science contents, all of which to make for meaningful science learning, and sociopolitical awareness.

Context of the research project

This study took place in an urban elementary classroom with students from eight different countries. They collectively spoke 14 different languages and/or dialects such as Somali, Oromo, Afrikaans, Swahili, Hmong, Creole, Karen, Vietnamese, and Spanish. Linguistic richness and knowledge from varied sociocultural experiences made the classroom an ideal space for students to infuse their experiences in science learning activities. Students possessed deeply personal and rich experiences based on their diverse linguistic and cultural skills. This made the classroom a good place for learning culturally relevant and personally meaningful science.

This study specifically focused on science lessons when the class used gardening activities as a context to learn different science ideas and topics. The class worked in the indoor classroom gardens twice a week during their regular science lessons. During these lessons, the teacher specifically covered the state science standards which were related to science topics such as seeds and seed germination, plant life cycle, weather, the food web, and water systems and cycles. The gardening lessons provided many opportunities for the students to draw from their sociocultural experiences for learning meaningful science.

Methodology

Case study

We used interpretive case study design (Merriam, 1988) to answer our questions because case study is 'the study of an instance [case] in action' (Adelman, Jenkins, & Kemmis, 1980, p. 48). In our study, the instance or the case was bounded by a group of six students. We followed them for the duration of the study (see Table 1 for the list of students and their characteristics). These students were purposefully chosen for the study because they actively participated in class discussions; shared their social, cultural, financial, and other knowledge and experiences freely; and pushed and challenged their peers and teacher, Ms Hope, while connecting science to their lived experiences.

Ms Hope had been an elementary teacher in inner-city urban schools for more than 12 years. She had been committed to inclusive and culturally relevant science teaching. She particularly focused on supporting her students to rely on their sociocultural and linguistic experiences in learning and engaging in science. For example, she would seek non-English-speaking students to prioritize their home experiences while making sense of science content and ideas such as replacing 'Brassica' activity with 'pea plants' while learning about the life cycle of plants. She also encouraged her students to, 'challenge [her] own ideas and their peers and bring their own knowledge in science.' She understood that providing an open and respectful environment in the classroom would encourage and support students from very diverse sociocultural experiences to actively participate in science learning. Ms Hope's commitment to student voice in science learning was based on her personal participation in inner-city community activities and seeing the efforts put in

Table 1. Student demographics and analysis.

Student	Ethnicity	Recent home experiences	Science and home connection
Lim	Hmong (Asian)	Gardening as a cultural, spiritual, and economic security	Practice of growing, harvesting, repurposing resources, and selling produce for economic gain
Jamal	Black	Food and food choices determined by housing crises and potential of losing home	Doing science and gardening at school could be part of finding science at home Science seen as a potential area of value in economic crises
Marquis	Black	Poverty and potential loss of home that determined what food to buy and volume of food versus healthy/variety in food	Food choices at home could be informed by science learned at school
Aisha	Black	Evicted from home and loss of economic and family security; concern about poverty	Science and home are integrally connected to learning about food, habitat, and aesthetics
Abdi	Somali (African)	Women and girls burdened by getting water from long distances, water accessibility was most important	Making linkages between science and the influence of environment and climate on easy access to water; science knowledge and access to water had strong connections
Carlos	Hispanic	Loss of family home during mortgage crisis, cost of heating home high because of poor insulation	Science learning at school informed by loss of family home, finding connections to the loss of polar bear habitat with his own experience of living in poorly insulated home
Katherine	Hispanic (El Salvador)	Loss of home and being displaced to a poorer neighbourhood	Learning and doing science linked to home experience with habitat loss for polar bear
Students not interviewed			
Antonio	Hispanic	Economic distress and economic security	Science of gardening easing economic distress
Martin	Kenya (African)	Water as an invaluable resource for survival and farming	Finding science knowledge to be useful knowledge for managing water and environmental factors on survival
Juan	Hispanic (Mexico)	Learning from elders by observing, doing and emulating	Science of hand pollination and food production
Alissa	Hispanic	Poverty and immigrant status determined healthy food choices	Science and healthy food choices were linked to foods available in stores; feeling of discrimination and shortage of food choices in local grocery stores

by students from nondominant groups to succeed academically but still struggling to find science learning relevant to their experiences. Therefore, Ms Hope's science class encouraged students to have their voice and power to guide the direction of science learning.

The case study design allowed us to understand and interpret how students gained voice and created empowering experiences for themselves in a science class. The case study design also allowed us to recognize the complexities of the classroom engagement and learning in the context of the students' sociocultural experiences (Nisbet & Watt, 1984).

Data collection

The data presented in this paper were collected over one academic year in a fifth-grade classroom. The gardening and science activities, interactions, and lessons were video recorded periodically, usually every other week. We video recorded six hours of classroom teaching over one academic year. Scheduling conflicts and time constraints demanded flexibility. We also collected students' classroom worksheets and journals for later analysis. We kept a field notebook that contained classroom observations and reflections of activities and interactions.

We audio recorded and transcribed 12 in-depth formal and 18 informal conversations with the students. The informal 5–10-minute conversations were held during their gardening classes. Each student was interviewed twice for 45–60 minutes; the interviews occurred during the course of the academic year for a total of 8 hours. We asked questions such as what made them think that science learned at school was useful, what kinds of science activities and science concepts they thought were useful, how they knew that science would help them succeed in life, and why they believed that science was connected to their life.

Data analysis

Our data analysis process was iterative in nature. We first carefully looked at the video tapes to discern what kinds of issues the students were bringing into science activities and discussions. We wanted to create a list of emerging themes from the video tapes before we engaged in analysing the interviews, field notes, and classroom artefacts. Therefore, we needed to select video episodes that directly helped us answer the questions that interested us in this study. Some of the major criteria employed to choose the video episodes were: students utilizing cultural referents to learn science and hold science discussions; students showing connections between their social, political, and financial experiences in the new contexts such as the recent financial crisis and science learning; students infusing culturally relevant knowledge and experiences during planning activities, discussions, and responses to their teacher's questions.

In developing our themes, we followed a mixed approach to our data analysis process – coding categories identified prior to analysis and inductive or grounded approach. The coding categories identified prior to analysis were based on our literature reviews and included codes such as 'science learning between people and culture; authentic science for nondominant groups; and culturally relevant and science activities'. The inductive approach to data analysis generated codes such as 'mortgage crisis as new cultural experience; youths and their new cultural experience – immigrants and non-immigrants; and sustaining native knowledge and learning science'. Based on this analysis process, we analysed the first two videotaped recordings and field notes and derived five themes: (a) mortgage crisis as an economic discourse in science, (b) connection of science to personal experiences, (c) global and local connections in science, (d) evolving cultural experience in young people, and (e) linking personal stories in legitimating science. We then connected and codified interview data with each of the themes in order to uncover students' reasons for learning science. Responses such as 'We had to eat pea soup to save money to pay bank', 'I learned [hand pollination] from my father', and 'My mom and sister didn't have to walk too far for water in Kenya refugee camp', permeated the interviews. We also allowed students to express their views and describe their experiences. We inquired about inconsistencies in their responses during one-on-one interviews. In the final step, we collapsed five themes into three larger themes to capture a better understanding of science learning in a continually evolving culture of students and the empowering experiences of students in learning science that was meaningful and connected to their global sociocultural experiences. The three themes that we present as our three findings are: (1) students gaining voice during science learning, (2) earning respect for their knowledge and self-determination, and (3) extending thinking and connecting science learning globally.

Findings

As stated above, we present three findings in detail below. The first finding presents the power of urban students' voices in science learning and making science content meaningful to them; the second finding showcases the culturally relevant science and how students' decisions provide actions for self-determination in science learning; and the third finding extends science learning for sociopolitical awareness and connects to their larger world.

Gaining voice during science learning

The drive to learn science and to seek potential connections to their own lives was influenced by their recent experiences and challenges at home. Students were not only concerned about the detrimental effects of their own and their friends' lives because of housing crises but also they saw the possibilities science could provide in making their lives better. Students in this class experienced a cultural gap when they had to learn about the life cycle of the mustard (*Brassica*) plant in their science unit. In order to bridge the gap between the school science and their sociocultural experience, they instead suggested to Ms Hope that they should learn the life cycle of pea plants. This was an example of students' gaining voice in deciding what kind of science activity they wanted to engage in to learn about the life cycle of a plant. The replacement of Brassica© plant with pea plant showed the value of sociocultural nature of learning science and also indicated that students' evolving cultural experience impacted science learning (Gutiérrez, 2002; Laughter & Adams, 2012; Rogoff, 2003).

During a lesson on the life cycle of plants, Ms Hope told the class that they would grow Brassica© plants to learn about a plant life cycle. The science content focused on learning the names and functions of the plant parts and how a plant grows from a 'small and inert seed to a big living thing', Ms Hope told students. On many occasions, we observed Ms Hope continuously draw students into sharing their home experiences and knowledge connected to science and provide them space to influence the focus of science activities and science learning. In this instance, Ms Hope opened the class asking for suggestions from students as to how they should go about 'doing this activity' or 'change the activity'. She was aware that many of her students, if given an opportunity, would suggest something more relevant to their home experiences. She was also convinced that 'Brassica plant was too foreign' for students to make sense of and find linkages between their experiences and the life cycle of a foreign sounding plant. Furthermore, she also knew many students avoided eating food that contained mustard such as a sandwich. The knowledge about her students' home and culture allowed Ms Hope to deliberately create an environment for them to gain voice in changing the nature of the *Brassica* activity.

As the brainstorming continued, students did not find learning about the *Brassica* plant useful in their lives, they instead suggested peas would be better. The students had a powerful and convincing discussion with Ms Hope in pushing her to replace *Brassica* with peas.

Jamal: At home, we eat lot of peas because it grows quickly and you get more
from one plant. Peas are healthier … We save money to pay the bank to
stay [in the house]. We have been eating pea soups for many months now … . We
never ate black beans before, but we eat that a lot too now … so we can stay in our
home …
Aisha: I ate pinto beans [brown bean] first time and we eat more because there is
less money for everything … I know that we eat peas and beans more than meat
now … My mom says we don't want to move to my aunt's again.
… … … … … … … ..
Ms. Hope: Brassica plant [grows] much faster than pea plants.
Aisha: I don't like mustard and how can you live eating that … and I don't
want to go live with aunt if we can't pay bank …
Jamal: Yah. I like pea plants and makes sense to learn about that.
Carlos: I don't know [much] about mustard because I don't think we
use mustard at home much. Learning about what I eat every day is better … and
helps family with food and savings … My mom said we needed to save to pay
for house [mortgage].
Aisha: Yah. We can try growing in class … why not Ms. Hope!
… … … ..
Ms. Hope: I like your suggestion. Today we will learn about the basic facts of
plants and tomorrow I will bring peas to grow. But today we have to learn science
[content] so we can jump into the activity setting up and planting peas tomorrow.

Science knowledge about peas helped them make sense of the current home experiences. Furthermore, the students felt responsible to contribute to their family so that the burden of saving their homes was shared among all family members. Students used the pronoun 'we' in lines 13, 15, 17, 26, 28, and 30 clearly showing that they were committed to helping their family to save money and contribute to home mortgage payments, even though in small ways.

Furthermore, Aisha found herself eating pinto beans for the first time in her life because of economic constraints at home caused by the mortgage crises. She expanded on her reasons for wanting to learn about pea plants rather than *Brassica* during the interview.

> If my family had used space behind our old home to grow peas we would have saved our home … The bank took our home because there was no money to pay and my dad lost [his] job in construction. … We now live in my aunt's home for almost one year now.

What motivated Aisha to learn about the life cycle of pea plants was similar to what made Jamal and Carlos interested in it. Aisha was further contemplating how they could have saved their home from foreclosure, if she had known more about growing peas or utilizing unused space for growing vegetables. Realistically, the space behind her home would not have saved the home from foreclosure, but Aisha could see a beneficial connection between science and her experience with economic disaster for the family. Aisha placed high importance on the science knowledge that was of immediate value because of her recent experience of having to leave the place where she had spent 12 years of her life. Jamal, Aisha, and Carlos contextualized science learning to their current environment at home rather than what the school curriculum (*Brassica*) demanded them to learn.

The first author later inquired about their choice for the pea plants. The students' responses were very personally connected and strongly framed by the mortgage crises they experienced:

Researcher:	Why didn't you learn about mustard?
Jamal:	You know, I think knowing about what we eat and like is better. It helps me to think and may be use small plot behind my home … one way to save money if you grow your own.
Researcher:	Why was that important?
Jamal:	My father lost job and my mom works but we [skimp] on food. I think knowing to grow peas [would] help and maybe I will like peas not the can kind.
Antonio:	My mom and dad work all the time and we can't pay for home … My father told us [three siblings] we will not get new things and same food. Um …
Researcher:	Would you tell me why learning about pea plants excited you?
Antonio:	I don't like can[ned] peas. We eat a lot now and when my mom buys [fresh] peas I like that. So I wanted to know more about peas than mustard. You know we don't eat mustard as food.
Carlos:	I don't like mustard and don't [even] put on anything I eat … I was excited to plant peas because this is something in science useful to me directly. I am happy we convinced Ms. Hope to plant peas and she agree[ed] and, you know, she listened to us.

Jamal, Antonio, and Carlos's reasons for learning about peas were based on the economic crises and their personal dislike for canned peas. The motivation was from their family's economic hardships and the concern for their parents' ability to keep their home from foreclosure. Carlos saw the activity on peas as a way to 'learn something in science [that was] useful to [his life] directly. I am happy we convinced Ms. Hope … she listened to us.'

The sense of loss among these students was profound, and the possibility of that loss was equally acute in other students in the class such as Katherine, who felt that her 'good friends went to another place because they lost home, and [she was] concerned about [her] own family.'

The change in Ms Hope's instruction and the standard curricular activities as prescribed by the school and the district meant that students gained voice in science class.

Their views, experiences, and preferences to learn science based on the evolving cultural experience and context of their lives received support from Ms Hope while learning science. Ms Hope was pleased that students gained voice and took control of their learning: 'I am excited that the students grabbed the opportunity to talk about a very important economic and personal issue and bring [them] into science … their voice was important for change in my science activity.' Thus, the students got their voice and opportunity to learn science content in their own preferred ways. Furthermore, the students utilized their knowledge gained from the recent mortgage crises to prioritize what new science concepts they would learn at school. The tasks of growing pea plants and later harvesting the peas were not just about learning science but also intimately about their lives and communities.

Many of these students came from neighbourhoods that had suffered severely during the global economic downturn. For many families, keeping their homes was as important as other everyday choices, such as what food to buy. Our analysis of interviews and class observations showed how students' recent experiences influenced their science discourses in the class. Learning science and engaging in science interactions in the class connected students to their sociocultural and socioeconomic realities of homes. Students discovered that they could gain voice in science class and co-opted their teacher to readjust science activities to align with their sociocultural experiences based on mortgage crises and interests.

Students' actions for self-determination in science learning

One of the core aspects of sociocultural theory and CRP is to foster actions from students to self-determine the course of science learning. These theories support science learning that generates science interactions that allow students to actively utilize science knowledge from home (Milner, 2011). Additionally, these theories also support the assertions that students show increased engagement and motivation (Dimick, 2012) when they are afforded opportunities to personally choose what and how they wanted to learn science.

In this class, students' took actions to self-determine science activities and content they wanted to learn. They decided to grow strawberries to learn about plant environment relationships, extended it to nutrition topics, and infused environment and food sciences with their home experiences. As a part of furthering science knowledge on environment and plants, students suggested that they should learn about 'a plant that [produced] fruit' instead of a vegetable like peas. Additionally, some students added that learning about fruits could connect environment topics with healthy food and nutrition. Students' actions to convince Ms Hope to grow strawberries included articulating and brainstorming how planting strawberries would help them learn many science topics and their relationships with environment and nutrition. Following are some students' remarks:

Lim: We can lean science [of] plant life cycle, healthy eating, and relationships between plants and environment … We want to grow our own [strawberries] and all food … and we [Hmongs] have close relationship to garden[ing] and food [we] grow

Aisha: We can eat fresh [healthy] fruit [with] no fertilizer and … chemical.

Katherine: It's easy to grow in class [with less] space.

Carlos: It's healthy [and] my grandpa, dad, aunts, and my brother [have] diabetes and heard them talk about this.

Abdi: We can learn how pea plant and this plant life cycle is same or different.
Marquis: I never get to eat strawberry because it's expensive because it's [transported] from South America.
Ms. Hope: These are all good reasons to grow strawberries and learn environment factors such as temperature, soil, and water that influence plant and also healthy food.

Students' reasons for growing strawberries to learn science contents had clear connections to their knowledge about nutrition, diabetes, and economics. Students' self-determination to learn science was clearly guided by what they valued and what was meaningful to their lives.

The students planted strawberries in March in several small containers. In their science notebooks, they wrote that there was no difference between growing peas and strawberries because both pea plants and strawberry plants flowered. Alissa and Lim had some experience growing strawberries on a large scale based on their families' jobs in farms. A couple of days later, when they were planting the strawberries, Lim suggested that they needed to put 'straw or something under the plants so the strawberries wouldn't rot … because they grew lower to the ground not up like that [pointing to pea plants].' Aisha added, 'It [straw] also helps save water so we don't have to worry [during] weekends.' As a result of Lim and Aisha's experiences at home, the class mulched with straw beneath the plants. Ms Hope saw the advantages to allowing the students to self-determine their activity.

Another important action related to students' self-determination took place when the class expected to get strawberries but they only saw numerous white strawberry flowers. Only two of the plants produced strawberries, with merely two berries per plant. The flowers just wilted away, which perplexed the class. Katherine asked Ms Hope and her peers if they knew why the strawberry flowers bloomed but without any strawberries. During this discussion, Andi and Jamal attributed this failure to their 'inexperience in growing strawberries.' Others guessed 'mold and fungus', some blamed 'too little direct sunlight', and a couple of them noted the 'cold weather'. In the class and also during the interview, Lim suggested, 'Maybe flowers needed some help, you know, like wind or insects or some other … I mean like connection between plant and environment' implying a connection between the flower and a physical action. Many of the above reasons were appropriate and scientific in nature. During the group discussion, Lim contended:

> if there [were] more flowers, there should be more strawberries because that's what I see in our garden plot … and the farm my parents work [in] … . the [mismatch] between the number of flowers and the number of strawberries didn't make sense … .but … .um … no insects in class.

Lim made important connections between the environment and the plant, but also added a potential role of insects. In the class and also during the interviews, Katherine stated, 'I wanted to know why we couldn't get strawberries.' Students asked Ms Hope for an answer but she had none. Students like Abdi determined that they needed to 'search the web and reference books'. The students concluded pollination is important and needs assistance from insects and wind. The students' search for an answer helped them learn about the relationships among environment, animals, plants, and pollination.

Related to the question of how to resolve the issue of pollination in order to grow strawberries, students knew the science behind it but still did not know how to carry out pollination in class. In order to solve this problem, Juan's experience with his family and the knowledge about hand pollination determined the course of action. Juan told the class about hand pollination. His peers and Ms Hope encouraged him to share his knowledge and teach them this process. Ms Hope told the class, 'This is new knowledge for me and maybe most of you too.'

Juan first told the class that he and his family 'pollinated by hand vanilla bean flowers' in Southern Mexico. He elaborated and explained about the 'la flor amarillo' and how to transfer the 'pollen to another la flor'. Everyone in the class, including the researchers, was surprised to know that Juan knew how to pollinate flowers by hand. Ms Hope asked Juan to demonstrate to the class the process of hand pollination as he had seen done. He showed the class how he would carry out the hand pollination and warned the class to be delicate and avoid damaging the flower:

> I use my finger and touch this flower [to collect pollen] and touch [another] *flor* flower. [This] mixes the *amarillo* yellow [pollen] of one flower [with another] … Be careful [with this] flower.

Juan's knowledge of hand pollination was deep and accurate, because even though he did not know the science of pollination, he was the only person in the class who could successfully pollinate strawberry flowers. His knowledge of pollination determined the success of this science lesson showing connections between home knowledge and students' ability to self-determine the course of science learning. His knowledge and skills on hand pollination were gained by watching and working with his elders, which was extremely valuable in the class effort to harvest strawberries. For the next two classes, Ms Hope taught students science behind 'natural pollination and artificial pollination' and why there 'need[ed] to be a balanced relationship between plants, insects, and the environment'. She would not have taught pollination, let alone artificial pollination, if students had not taken control of what they wanted to learn in science and if Juan had not shared his knowledge learned at home.

After Juan's demonstration of hand pollination, his peers and Ms Hope hand pollinated strawberry flowers in the class. After a week, a number of strawberry plants produced strawberries. Although some plants did not bear fruit, what is worth noting is that students not only learned about pollination but also hand pollination. Lim's comment in the interview captured the importance of knowledge from home and their ability to self-determine science learning:

> We were able to tell Ms. Hope what we wanted to do and learn. We decided our activity and designed and learned hand pollination … we won't have learned hand pollination if in the class we didn't decide our own science activity.

Juan's cultural repertoire of hand pollination was invaluable for students' success in harvesting some strawberries, learning about pollination, connection between knowledge from home and science, and students' ability to self-determine science activities and content. Students' desire to save the strawberries from rotting and Juan's sharing of his hand pollination knowledge were examples of how students utilized their knowledge from home and their self-determination to learn the science they wanted. The value of sociocultural experiences and knowledge from home was evident in their meaningful and empowering science learning engagement where they self-determined the activities and the science content.

Science learning for sociopolitical awareness

Sociocultural theory of learning and CRP advocate for learning to be more than just content mastery. These theories assert that the value in learning content comes from students' ultimate ability to make critical and conscious linkages between science and larger sociopolitical inequities. We believe that a core aspect of learning science is to build students' competence to critically examine sociopolitical and sociocultural issues there by seeing links between science learning and larger communal and global issues. This kind of link building generates awareness in students to understand sociopolitical nature of a situation, analyse and question the status quo, and actively try to change it (Ladson-Billings, 1995a, 1995b). We believe students in this study leveraged their sociocultural experiences to build sociopolitical awareness.

Students in this class brought highly diverse experiences representing eight countries including the U.S. Below we share an instance to illustrate how students utilized their own sociocultural experiences to build sociopolitical awareness and help extend their critical thinking beyond classroom science.

As a part of school science curriculum and gardening, students were learning about the environment and its influence on water distribution, access, and implications of water in their lives. The lessons on access to water and its influence on people and food production started off with students, who had recently immigrated from Africa, Asia, and Latin America, talking about their and many others' struggle to get clean water for everyday purposes and for their small subsistence farming back in their home countries. In many places around the world, including large cities such as Mexico City and in 'Kenya and Somalia, people spend a lot of time to get [clean] water … and lot of them don't get it easily' [Abdi]. Martin shared his understanding about different forms of water and how they affected his family's life in Kenya:

> My mother and sisters and sometimes me travelled long distances to get clean water in my village … but people in cities get water supply to their homes … I don't understand why our village not get water … I'm interested to learn about water and how it gets given [distributed] to some …

Similarly, during an interview, Abdi connected Martin's experience with his family's experience in a Somali refugee camp in Kenya:

> When Martin talked about his mother and sisters walking to get water, I forgot, now living in America, that my mother and sisters and aunts don't have to walk to get clean water for like 12 to 16 people … Clean water comes to your tap … My friends who grew in America don't think about water not coming out of tap … I think this is unfair and learning in science class about water, water for food growing, and environment, helps me think why it's not fair to other people who live in poor countries.

Martin and Abdi drew connections between science and larger water inequity issues from their home experiences. They questioned why people in villages and 'refugee camps in Kenya don't have easy access to clean water'. Martin specifically wondered why people in his 'village didn't get access to water but city people got it'. Abdi voiced inequities imbedded in the distribution of water and who got access to water. Martin and Abdi both showed sociopolitical awareness about how unfair access to water had influenced women and girls in their family.

Similarly, Alissa and Katherine both voiced the burden of accessing and providing water to family mostly fell on women and girls in the family. They appreciated that in the U.S. 'women and girls don't have to worry about spending lot of time to get water', stated Alissa. The science class helped them to rethink and be aware of inequities in their own lives.

Katherine and Alissa attributed their understanding of inequities in water access to the science class. They also became aware that women and girls took the majority, if not all, of the responsibility in ensuring access to water for their families.

> Katherine: I think we [mothers, sisters, and aunts] were doing normal thing getting water. In this class I learned from Martin and Abdi talking how their mothers and sisters walked to get water and I [was] doing same thing … Remind[s] me not fair that some have to walk to get water.
>
> Alissa: I didn't know that mothers and sisters got water and walked so far. Here [USA] we just don't have to do that. That's lot of work … I am now thinking, um, people worked hard to get water for family. That is new to me and I learned here to ask more question and, um, not fair to walk that far [for water].

The sharing and blending of sociocultural experiences with science activities and contents generated sociopolitical awareness in Katherine and Alissa.

Students in this class further linked the distribution of water with farming. They were curious if water distribution had an impact on the availability of unseasonable fruits and vegetables in their grocery stores. This question was linked to how the seasons and more broadly the environment influenced food cycles and water cycles in a local environment. Jamal wondered, 'How water gets divided in places, like places, we get our fruits and vegetables [from]? Does everyone gets to use same amount of water? You know like where they grow green beans and stuff.' Similarly, Aisha asked in the group discussion:

> Why do we [in the US] bring these food when it's not grown here? Like I heard Martin, Abdi, and Katherine talk about not getting enough water to clean and drink. Why not improve that and how can we do that [not share water with poor]?

During the interview, she elaborated her thinking as such:

> I think when we learned about preserving water, like rain collection or collecting snow and melting [into] water here in our state and we measured and built water collecting container [with] empty plastic milk [gallons] … I can now say we can collect all this [rain] water and use in our gardens or like cleaning other things … this can help give water who don't get it.

Jamal and Aisha were asking sociopolitical questions connecting science to fairness in sharing water resources and accessibility. Alissa's question on the importation of food to the U.S. directly connected her to the imbalance between the unfair distribution of water resources in many parts of the globe and different ways of saving water. Learning about the need for healthy food and food production and their links to water access generated a space for Jamal and Alissa to connect science to the larger sociopolitical issues regarding access to clean water.

Students further extended science contents surrounding plant habitat, environment, food production, and water to their home experiences and larger sociopolitical issues.

> Jamal: … Yah … so less rain in summer and rainy time nowadays, like, food growing places like California, Mexico, or Kenya, so food is less because of less rain … and costs more to buy … and hard to live healthy with no fresh food …

Alissa: … yah. We have to buy only can[ned] food …
Aisha: … and we also get less water like they [city] say don't water yard or something.
Ms. Hope: Yes. During summer, when there is less rain city passes ordinance to only water on even and odd days to save water so there is drinking water.
Marquis: Yah. So like one time there was very little rain like in some place and the food was expensive and we didn't buy lot of things [fresh vegetables]. And like, you know, Lim was telling that last [two] year[s] his family make less money selling food [vegetables] because [of] less rain …
Martin: … this happens all the time [frequently] in my village [in Kenya]. We have to be save water, food, everything for later use [future].

Knowledge about how weather influenced the growing season helped students notice some connections among weather, food, economy, and water rationing. The students built linkages between science of seasons, rainfall, and drought with food production, economic cost to families, and water distribution. Jamal, Alissa, Marquis, and Martin directly linked science with how their families had to make decisions about what food they ate, as well as how they managed family budget and long-term food security. Similarly, they tied science learning with their friends in the following ways:

Marquis: Now we can connect to friends who came from other places.
Martin: Now I know my knowledge is useful in other places … like everyone needs *maji* [water in Swahili] and just like us [Kenyans], we eat, um, *ugali* (corn meal) in school lunch here [US].

Marquis and Martin both not only connected science to their in-school and out-of-school experiences but also exhibited sociopolitical awareness which allowed them to tie science learning with their own and their friends' experiences on access to food and water.

Science content knowledge and related activity on collecting rainwater and melted snow for later usage in different ways were guided by students' sociocultural, economic, and access experiences. These personal and global experiences provided meaning to science learning. Moreover, the instances of infusion of sociocultural experiences in science class helped students to tie science to broader sociopolitical issues (Fereire, 1996) and to form sociopolitical awareness. Sociocultural theory of learning and culturally relevant engagement opportunities aided students in learning science for sociopolitical awareness and in globally diverse spaces.

The three findings of this study indicate that sociocultural theory of learning and CRP builds competence and capability in students to gain a powerful voice, influence science content and activities, and generate sociopolitical awareness because students are capable of infusing their sociocultural experiences in learning science and determining science activities for their learning.

Discussion and implications

This study highlights and extends the relevance of sociocultural experiences in learning science and shows the power of students' 'shifting and evolving' (Paris & Alim, 2014, p. 95) culture in determining science activities, contents that students prefer to learn, and awareness of inequities. Instead of treating the culture of a student as embodying 'static traits' (Gutiérrez, 2006, p. 43; Paris, 2012), we followed their conceptualization of culture as continuously evolving and shifting with each new experience (Ladson-Billings, 2014) thereby making science learning meaningful and empowering for the students.

Our study underscores that crediting students' cultural knowledge, new sociocultural experiences, diverse skills, and diverse funds of knowledge (Gonzalez, Moll, & Amanti, 2005) allowed them to gain voice and power in deciding what science they wanted to learn. This study suggests that students from nondominant groups can incorporate relevant and sophisticated knowledge and skills into learning science. We believe that the hand pollination and *Brassica* replacement with pea plant life cycle were clear illustrations of the influence of sociocultural experiences on science topics and science activities. This finding agrees with Ladson-Billings (2014) and Paris's (2012) findings and arguments that when students' shifting and evolving cultural experiences are parts of learning science, students build personal connections between science and their rich social, economic, and cultural contexts.

This paper suggests that the students' desire to learn science was grounded in their current life experiences at multiple locations such as at home, a rental property, a farm in Kenya and Mexico, and a refugee camp and helped them influence their teacher's instructional decisions for academic success (Azevedo, 2011; Brown, 2004). We also documented that students built sociopolitical awareness based on their daily lives through their studies about the water cycle and its relationship with food production and water preservation. These interests allowed students to critically examine their own situations and to rethink and re-analyse the effects of water, food production, food purchasing power, and access to financial and natural resources on their families and communities. This indicates to us that teachers and science education researchers need to perceive the value of both the culturally responsive instruction (Parsons, 2008) and sociocultural idea of learning as assets based pedagogy that supports culturally pluralistic and democratic practices and challenges social inequities by critically examining them through science (Brown, 2004; Emdin, 2010; Ladson-Billings, 2014).

The three findings of this study agree with Ladson-Billings (2014) and Paris and Alim (2014), who propounded that teachers and scholars of science education need to consider sociocultural theory and CRP to 'incorporate multiplicities of identities and cultures' (Ladson-Billings, 2014, p. 82) of their students in new global and local contexts that challenge the status quo and sociopolitical inequities. Thus, science education should view students' sociocultural experiences to embody evolving youth cultures (e.g. hip-hop, instant messaging) more prominently.

This study suggests that urban science teachers and urban science education scholars who seek to assist and explore the experiences of students from nondominant groups in science contexts must (a) pay more attention to understand that students' culture is more individualistic and fluid and (b) imbed students' skills and knowledge from home and other sociocultural experiences into science classroom instructions for sociopolitical awareness. This study adds new knowledge to the limited research in science education that explores sociopolitical consciousness and awareness (e.g. Brown, 2004).

Sociopolitical consciousness is central to both culturally responsive pedagogy (CRP) and sociocultural theory (CST). We believe sociopolitical consciousness is the least addressed aspect of CST and CRP in most science education research and teaching. Sleeter (2012) argues that the success of CRP as a pedagogy relies on the commitment of science teachers to make science teaching and learning a 'political endeavor' (p. 577).

One of the reasons for the marginalization of teaching science for sociopolitical consciousness and empowerment is that many traditional science teachers and science teacher education programmes put more emphasis on decontextualized nature of teaching science content. Furthermore, many traditional science teachers use CRP and CST pedagogies in their teaching more as a cultural celebration and essentialization (e.g. Patchen & Cox-Petersen, 2008; Sleeter, 2012) of students' culture, language, and home experiences rather than contextualizing science learning and engagement for critical consciousness and empowerment. Based on our findings, we believe science education needs to encourage science teachers to infuse CRP and CST pedagogies more in their teaching to make science learning relevant to students from nondominant groups. Additionally, we also believe that CRP and CST, unlike traditional science pedagogies, provide powerful equity pedagogies to empower and build sociopolitical consciousness in students through science education.

Therefore, there needs to be more research that focuses on exploring how sociopolitical consciousness is encouraged, sustained, and valued in science classrooms. Additionally, research should be expanded to explore sociopolitical consciousness in the context of globalization which in turn could add to better understanding of science education in the global contexts. This study alludes to the value of incorporating rich knowledge and experiences of urban students in meaningful science learning for academic success and sociopolitical awareness.

Disclosure statement

No potential conflict of interest was reported by the authors.

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