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Using Transformative Boundary Objects to Create Critical Engagement in Science: A Case Study

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ABSTRACT: Teachers are increasingly faced with questions of how to teach the students in diverse classrooms in ways that are responsive to their experiences outside of the classroom. This paper presents a case study of how one 6th-grade teacher in a midwestern city enacts the Choice, Control, and Change (C3) curriculum, a curriculum based on the concept of dynamic equilibrium (energy in/energy out) in science-rich and culturally relevant ways. We analyze how she used what we call "transformative boundary objects" to leverage students' cultural knowledge and experiences of food and activity practices and systems to support the learning community in (a) developing an awareness of and trying on the norms and practices of science and (b) legitimizing the values, discourses, and practices of their everyday lives, the first two tenets of Ladson-Billings (1995a, 1995b) culturally relevant teaching, to transform the traditional discourses and practices of school science. We particularly focus on Ladson-Billings third tenet, (c), the development of critical consciousness, showing

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how the teacher uses transformative boundary objects to transform science learning into a context where traditional boundaries between students lives and school science are blurred, and a critical consciousness about how the food system works and its connections to their everyday food choices is supported. *Sci Ed* **97:**1–31, 2013

INTRODUCTION

Teachers are faced with the question of how to best teach all of their students, regardless of background (i.e., race, ethnicity, socioeconomic status). Educators have developed "culturally relevant teaching" (Ladson-Billings, 1994, 1995a, 1995b) and "culturally responsive teaching" (Gay, 2000) to address how teachers should pay explicit attention to and leverage students' experiences, including their knowledge and skills from their lives outside of school. At the same time, in science education, teachers are also faced with the challenge of supporting all learners in engaging in scientific concepts and important science practices, such as asking research questions, developing, testing and revising scientific models, collecting and analyzing data, building evidence-based claims, and reporting findings (National Research Council, 2011), even when such practices do not *obviously* align with the knowledge and experiences that students bring to the classroom. Ladson-Billings' tenets of culturally relevant teaching encompass the goals of (1) academic success in school subjects, (2) promoting cultural competence, and (3) helping students to develop a critical consciousness through which they challenge the status quo (Ladson-Billings, 1995a, 1995b). However, examples are needed of what this looks like in science classrooms, particularly related to the third tenet—critical consciousness. In this article, we present a case study of one teacher, Mrs. Hanson,[1] who taught her sixth-grade class an inquiry-based curriculum unit about the big idea of dynamic equilibrium (energy in/energy out) in the context of the human body. The purpose of the article is to make sense of how one teacher's pedagogical practices is consistent with Ladson-Billing's three tenets, especially how she helped students develop critical consciousness, while learning science and being responsive to her students' everyday practices.

RETHINKING THE GOALS OF SCIENCE EDUCATION: FROM ACCULTURATION TO CRITICAL CONSCIOUSNESS

Culturally Relevant Pedagogy and Critical Consciousness

Traditional school science typically does not privilege students' experiences and practices outside of school, positioning school science as potentially disconnected from and not necessarily relevant to students' everyday lives (cf. Aikenhead, 1996; Brickhouse, 1994; Upadhyay, 2006). Thus, it has been a central tenet of equity-driven research in science education for nearly two decades that one important role of science education is acculturation, the notion that students ought to be provided with opportunities to become fluent in the norms and practices of science (and school science) and to learn how they are expected to participate through discourse, ways of knowing, and practices (Aikenhead, 1996; Fradd & Lee, 1999). The construct of acculturation has been central because it has helped to make clear the complex challenges that many youth face as they are expected to cross borders between their "home-based cultural worlds" and the "world of school science" (Moje, Collazo, Carrillo, & Marx, 2001).

Students participate in many "worlds," such as family, peer, and school worlds. Transitions between these worlds can be difficult for students, as they are governed by different

[1] Pseudonyms are used for all people and places.

values and norms, yet students' ability to move between worlds or settings has implications for students' chances of using education as a stepping stone for future work experiences and life opportunities (Phelan, Davidson, & Cao, 1991). Rogoff also reminds us that students participate in many communities and activities all of the time and

> Whether the activity is an everyday chore or participation in a test or a laboratory experiment, people's performance depends in large part on the circumstances that are routine in their community and on the cultural practices they are used to. What they do depends in important ways on the cultural meaning given to the events and the social and institutional supports provided in their communities for learning and carrying out specific roles in the activities. (2007, p. 6)

This quotation reminds us that culture is not a static set of traits by which to identify a given group of people. Rather, it is dynamically constructed over time as people participate in socially "mediated, historically developing, practical activity involving cultural practices and tools" (Gutiérrez & Rogoff, 2003, p. 21). Ladson-Billings discussed how all individuals are cultural beings who are part of cultural systems, and individual actions should be recognized as "learned behavior that has been normalized and regularized" through patterns over time (Ladson-Billings, 2006, p. 109). We believe that learning is a cultural process and that it is important to understand how culture shapes students' learning and experiences.

The ways in which acculturation plays a role in how science is taught has also been central to discussions of culturally relevant approaches to science teaching. Culturally relevant pedagogy (CRP) is "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (Ladson-Billings, 1994, p. 18). From a CRP perspective, one of a teacher's central roles in the classroom is to create bridges between students' home and school lives while still meeting the expectations of the district and state curricular requirements. Some have argued that the goals of acculturation and cultural relevancy are congruent in that both underscore the vital importance of creating learning opportunities that provide explicit access to the norms and practices of science or the culture of (Western) science (e.g., Lee, Luykx, Buxton, & Shaver, 2007; Varelas, Becker, Luster, & Wenzel, 2002). However, there are differences in how scholars describe the role and importance of students' backgrounds, knowledge, and experiences in the process of acculturation and even the goals of acculturation itself. Some argue that the primary goal is to support students in taking on the secondary discourse of science in exchange for their primary discourse in a kind of code switching or bilingualism (O. Lee, 2005). Others argue that primary discourses should "merge" with the secondary discourse of science allowing for a transformed hybrid discourse that provides access to science (Calabrese Barton & Tan, 2009; Moje et al., 2001, 2004). Still others argue that there is great continuity between the discourses of science and that of children, although this continuity often goes unrecognized (Rosebery, Ogonowski, DiSchino, & Warren, 2010).

Despite these differences, it is widely agreed upon that all students should have opportunities to gain access to the culture and practices of science. Furthermore, most of these scholars agree that such opportunities are important and necessary to ensure that students have academic success in school subjects and to promote cross-cultural competence, two of the tenets of CRP. Despite agreement on the value of providing explicit access to the culture and practices of science, there has been minimal uptake of Ladson-Billings' third goal of CRP—to support students in developing "a critical consciousness through which they challenge the status quo of the current social order" (1995a, p. 160). This latter point has been given little attention in education in general and science education circles in particular (cf. Morrison, Robbins, & Rose, 2008). Yet we think it raises important questions regarding why and how students engage science and that it has bearing on students being successful in CRP's tenets one and two.

While there has been little uptake of Ladson-Billings' third goal of CRP, critical consciousness, there are studies that focus on critical consciousness in science education (although not tied to the broader goals of CRP). Upadhyay's (2010) study of two teachers' perception of social justice–oriented science teaching found that part of working toward social justice was "working against institutional oppression and inequalities" (p. 69). Likewise, Buxton's (2010) examination of place-based curriculum in an informal summer program provides rich insight into how integrating place-based concerns with meaningful scientific inquiry challenged learners "to interrogate social inequities and power dynamics that influence the way people live" (p. 123). This outcome, according to Buxton, proved to be pivotal in students more traditional forms of academic success in the program. Calabrese Barton and Tan (2009) studied how power shifted in the classroom when a teacher co-constructed curriculum with students, supporting students in purposefully leveraging their nontraditional funds of knowledge toward required science learning goals. Normative roles and routines were reconfigured in the physical space of the classroom as teachers and students refigured themselves socially and against the normative hierarchy imposed by schools. While these scholars do not tie their work to CRP, it is consistent with Ladson-Billings' idea of critical consciousness.

We believe that acculturation—even when thoughtfully and carefully conceived to call attention and value to students' cultural practices—is too narrowly focused on the discourses and practices of school science to bring about successful science learning *with* critical consciousness, Ladson-Billing's third tenet. We agree with Young (2010) that the dominant interpretation of CRP focuses primarily on teaching students to "cross borders" while also learning to maintain a strong sense of one's cultural self. This interpretation, Young points out, neglects what and how it means to develop critical consciousness. In fact, little has been written about how CRP promotes critical consciousness or what critical consciousness means in the spaces of subject matter learning (Young, 2010; see also Gay, 2000). In their review of classroom-based research on CRP, Morrison and her colleagues (2008) found fewer examples of the critical consciousness tenet than the other two areas of CRP, but argue that critical consciousness serves as a capstone to CRP. Furthermore, in what is written, there is little consensus on what CRP is, especially with respect to critical consciousness (Young, 2010). In her original writings, Ladson-Billings (1995a) has described critical consciousness in CRP as framed by attention to recognizing, critiquing, and seeking to transform social inequalities. Morrison and her colleagues categorized studies that included critical consciousness as part of CRP into four categories: critical literacy, engaging students in social justice work, making explicit the power dynamics of mainstream society, and sharing power in the classroom. But how critical literacy or engaging students in social justice work was enacted in each classroom varied. For example, studies that fell into the social justice category included students who provided services to their communities as part of the curriculum to teachers promoting values of caring for other human beings through encouragement of good qualities of students. More recently, supporting critical consciousness as part of literacy instruction has been described as when students "know their authentic stories, are able to stand up for themselves, and ask questions about the world around them" (Matthews, 2010, p. 1).

But what does it mean to know one's stories, stand up for oneself, and ask questions about the world around them in the context of science class? We suggest that one way to think about culturally relevant learning that includes the development of critical consciousness is to move beyond conceptualizations of crossing borders or boundaries to a focus on "critical intercultural exchange" (Gutierrez, 2008, p. 148). According to Gutierrez, "Critical intercultural exchange" in the classroom involves a colliding and merging of worlds in ways that are "contingent upon students' sociohistorical lives, both proximally and distally" (p. 149). Such exchanges (a) privilege students' lives in the context of disciplinary learning and (b) allow for the "practices of different communities to meet, collide and merge" (p. 150). CRP that supports the development of critical consciousness helps us to understand that any act of acculturation must take into account how people are different, how they can learn and be transformed by such differences, and how they critique their interactions with the many communities within which they participate. Indeed, as cultural individuals, we are always in the process of assigning meaning to tasks and activities in ways that merge the communities in which we traverse.

In schools, teachers must help students recognize and critique the current social order at the same time that they do so themselves. While students participate in many communities outside of school and they bring the knowledge and practices from these communities into the science classroom, their knowledge and experiences are not always sanctioned. We recognize that teachers often hold much of the power and authority in a classroom. Thus, it is classroom teachers who often sanction students' knowledge and experiences, which in turn creates or impedes the development of critical consciousness. This point is particularly salient, as we believe that productive critical intercultural exchange should revise and transform traditional boundaries. It should empower students to make informed decisions based on their understanding of the science and to use their experiences to change the science classroom learning community and potentially their everyday practices as well.

CRP and Dynamic Equilibrium

We are particularly concerned with CRP in the context of a sixth-grade unit on dynamic equilibrium in the human body. As discussed later, the unit uses an investigation into healthful food and activity choices to help students make sense of and apply the scientific ideas of dynamic equilibrium to themselves. What matters here, from a CRP lens, is the idea that not all youth are positioned in the same ways within the food system in the United States. Thus, for a unit on energy in and energy out in the context of healthful eating and activity choices, it is important to consider the general local cultural practices of the broader community, knowing that any given family may have their own unique practices. Ladson-Billings (2006) argues for the importance of examining the community, school, and societal factors that impact individuals and their choices, using unhealthful food practices as one example.

It is national news in the United States that childhood obesity and adolescent type 2 diabetes are at epidemic levels, particularly among urban low-income racial/ethnic minority children. For example, childhood rates of obesity (body mass index ≥95th percentile for age and sex) have tripled in the United States over the past four decades so that about 18% of 6–19-year-olds are now estimated to be obese and another 15% are overweight (85–95th percentile) (Ogden, Fryar, Carroll, & Flegal, 2004; Ogden, Carroll, Kit & Flegal, 2012). Many studies have confirmed that the rates of obesity and overweight are highest and rising fastest for African American, Hispanic, and Native American children living in low-income and urban communities, where the rates are 20%–26% and 19%–20%, respectively (Ogden et al., 2012).

There are many cultural practices that cut across racial and ethnic lines that characterize life in lower income, urban settings. The average child sees 10,000 food advertisements per year, most of which are for less healthful foods and beverages, and fast food abounds in all communities. One study found that African American adolescent boys watch more television and are exposed to 1.6 times the number of food advertisements compared with their White peers, and fast food is the most frequently viewed food product category (Powell, Szczypka, & Chaloupka, 2007).

Racial/ethnic minority and low-income youth have greater access to soft drinks and soft drink advertisements and promotions in their schools (Johnston, Delva, & O'Malley, 2007). The rapid spread of fast food, which is high in fat and salt, is a growing challenge in the low-income urban communities, and Great Lakes City, where the study takes place, is no exception. *Fast Food Nation* (Schlosser, 2001) outlines the growth of fast food as a U.S. phenomenon, and more recent studies point to its pervasiveness as a primary food source in communities with limited access to or ability to afford higher quality food. For example, a recent large-scale National Institutes of Health study (Baker, Schootman, Barnidge, & Kelly, 2006) revealed that the

> spatial distribution of fast food restaurants and supermarkets that provide options for meeting recommended dietary intake differed according to racial distribution and poverty rates. Mixed-race or white high-poverty areas and all African-American areas (regardless of income) were less likely than predominantly white higher-income communities to have access to foods that enable individuals to make healthy choices. (p. A78)

Taken together, the evidence suggests that interventions must be directed at physical activity and dietary intake and at changing both environmental factors and individual behavior. However, the elements of effectiveness and relative importance of the factors are not known (Giles-Corti & Donovan, 2002). There is increasing recognition that a supportive environment is important for obesity prevention including a health-promoting school food and physical activity environment (Institute of Medicine, 2007). We argue that teaching that is consistent with CRP can provide that supportive environment where students can learn about and apply the science of dynamic equilibrium in ways that support youth in critically navigating the particular features and constraints of their food and activity environments.

CRP and Boundary Objects

CRP pushes us beyond the traditional goals of acculturation, that is, how students move from novice (not knowing) to expert (knowing), to a more robust orientation that captures how the ability to move within and across communities of practice is integral to learning. In trying to locate the teaching practices that facilitate the development of critical consciousness, we turned to the concept of boundary objects.

Star and Griesemer (1989) used the concept of boundary objects to explain how museum workers from diverse communities develop common understanding by working together with objects. These objects, which they termed boundary objects, hold different meanings in different social worlds, but have a structure common enough to be recognizable and serve as a means of translation across social worlds. Star and Griesemer discussed that boundary objects work by forming shared spaces of increased communication and autonomy. Wenger (1998) further argues that boundary objects are based upon "reification," which is "the process of giving form to our experience by producing objects that congeal this experience into 'thingness"' (p. 58). In this sense, boundary objects are concrete, stable objects that coordinate activity across the communities they span. Thingness, however, has been an elusive term in the literature on boundary objects. Some have argued that thingness is constitutive of the "focal points around which interconnections between communities emerge" (Cobb, McClain, Lamberg, & Dean, 2003, p. 19), and that boundary objects themselves do not actually carry meaning across communities. Others have argued that "thingness" is made visible as infrastructure for the mediation of knowledge integration. In this way, boundary objects also offer "interpretive flexibility" in how they are pliable enough to "adapt to the specific needs and the constraints of both worlds" (Trompette &Vinck, 2009, p. 4).

Boundary objects do not bridge communities by themselves. Rather, boundary objects bridge communities in the ways they are taken up by the members of the different communities. C. P. Lee (2007) advances this argument by suggesting that boundary objects can also perform another important role. By "pushing" on boundaries rather than merely transgressing them, "artifacts can serve to establish and destabilize protocols themselves and that artifacts can be used to push boundaries rather than merely sailing across them" (p. 307). This last point is particularly important because of our interest in the role of boundary objects in fostering critical consciousness. However, the vast majority of the literature on boundary objects stops short of noting this potentially transformative role of boundary objects. In our article, we develop the idea of "transformative boundary objects" to capture the idea that we are interested in *those reifications that not only coordinate activity and allow for knowledge integration across worlds but also allow for the transformation of either the participating communities or of the nature of the boundary itself.*

It is our conjecture that transformative boundary objects, when taken up by teachers and students as means for trying on the norms and practices of science while also legitimizing the cultural experiences that they each bring to the process, aligns with the goals of CRP. The construction of transformative boundary objects has the potential to bridge but also break down and transform boundaries. With the mediation of transformative boundary objects, previously distinct communities important in students' lives (e.g., home and school) become less insular as meaningful threads of connection start to emanate. These transformative boundary object threads help create more powerful science learning opportunities where students can critically examine how science applies to their lives in ways that matter to them both inside and outside of the classroom. We argue that such powerful science learning opportunities are made possible when the science classroom learning environment becomes a place where student home communities and the school science community are not only equally valued but also are equally essential for meaningful science learning to take place. In this study, we examine two questions:

- How does Mrs. Hanson support students' development of a critical consciousness of science and their personal communities?
- In what ways are transformative boundary objects used in Mrs. Hanson's classroom, and how does this impact the goals for learning in science class?

METHODS

Setting

Mrs. Hanson. Mrs. Hanson is an experienced, White, teacher in her 40s. She teaches sixth-grade science at City Middle School. Mrs. Hanson is well known and liked in her school and in the district. Before we started working with her, many people—teachers and district administrator's alike—referred to her as a teacher to get to know. She had an easy rapport with administrators and students. We noticed her joking easily with the school assistant principal over both academic and nonacademic issues, and while strict with students, we observed her talking to them informally before and after class about topics that ranged from science homework help to weekend fun activities.

Mrs. Hanson's Students. The school in which Mrs. Hanson teaches houses Grades 6–8 and has approximately 670 students. The school is located in a city in a midwestern state that is one of the most economically depressed in the country. Unemployment rates for this city hover in the midteens, and a walk around the school neighborhood reveals many foreclosed homes and homes for sale. However, the school building itself is new, bright, and welcoming. It also sits in close proximity to a newly zoned urban residential neighborhood with new homes and homes under construction. Immediately surrounding the school are convenience stores, fast food restaurants, and local neighborhoods. We have also observed on a regular basis, students before and after school, or during lunch or break times snacking on fast and convenient food options.

It is important to note that much of the research about CRPs are studies about homogeneous classes of students, such as all African American classes or all Latino/a classes (Morrison et al., 2008). Mrs. Hanson's class is fairly heterogeneous with respect to the ethnic and racial backgrounds of her students. Her class demographics mirror that of the school, with approximately equal numbers of male and female students, and with 44% students categorized as Black, 31% White, 21% Hispanic, 5% Asian/Pacific Islander or American Indian/Alaskan Native. In our Findings and Discussion sections, we report on students' eating and activity practices, the culture of Mrs. Hanson's classroom, and how the classroom (school science) and students' practices are transformed.

C3 Curriculum

The Choice, Control, & Change (C3) curriculum is a reform-based, inquiry curriculum developed at Teachers College, Columbia University (Koch, Contento, & Calabrese Barton, 2010). It consists of five units, which are broken down into 19 lessons centered on the idea of energy in, energy out, or dynamic equilibrium in the human body. The overarching question for the curriculum is, "How can we use scientific evidence to help us make healthful food and activity choices?" Throughout the curriculum, the students investigate factors that influence their food and activity choices such as their physical environment (e.g., food sources in living environment), biology, and social environment (e.g., family choices, media influence).

Data Collection and Analysis

The first two authors were participant observers in the classroom. While Mrs. Hanson was addressing the whole class, we videotaped the classroom or sat near the back taking fieldnotes. When the students were working individually or in groups, we would often walk around the classroom, look at what the students were working on, and answer questions the students might ask us about the lessons. We focused on two of Mrs. Hanson's classes. These classes were not labeled as "advanced" nor were they classes that required an aide because of a high number of English language learners or students with special needs. We videotaped 13 class sessions from one of Mrs. Hanson's classes and observed in several others, including a field trip to the anatomy and physiology lab at a local university. We also conducted a series of three videotaped interviews with two conversation groups of students (four students per group) during which we asked the students about their experiences with the curriculum. The students were chosen with the help of the teacher; we wanted approximately equal numbers of males and females and groups that represented a mixed range of ability based on the teacher's identification. The interviews took place at the beginning, in the middle, and near the end of the curriculum enactment. As part of the curriculum, the students also choose goals related to their eating and activity practices, and we asked students what their goals were, about challenges related to achieving their goals, and whether they learned anything in the curriculum that helped them work toward their goals. We also asked the students general questions about the curriculum such as what they learned and which lessons they liked. We also interviewed Mrs. Hanson at the end of the curriculum enactment to get feedback on the curriculum enactment. We collected student artifacts, such as the student workbooks, student posters of their Unit 1 research project, and student posters of their public service announcements (PSAs) (see Table 1).

Interviews and class lessons were transcribed and reviewed by each member of our research team. We then used a multistep process for coding data. First, we initially applied a constant comparative approach (Glaser & Strauss, 1967; Patton, 1990) to our different data types (interview, class lessons, student work) that attended directly to the three goals of CRP: to ensure that students have academic success in school subjects, to promote cultural competence, and to help students develop a critical consciousness through which they challenge the status quo of the current social order (Ladson-Billings, 1995a). Once we grouped data by category, we began to code for relevant ideas within each category. We compared codes and ideas across category looking for commonalities as well as critical points of divergence. This initial process enabled us to reasonably chunk the data in a way that might help us to establish relationships across CRP goals in terms of student outcomes and teacher actions.

We then applied broad questions across our three categories: How did Mrs. Hanson enact a pedagogy that was responsive to important science practices and to the students' cultural knowledge and experiences? We examined how Mrs. Hanson helped her students understand the science, how she helped promote cultural competence (how she drew on students' everyday experiences outside of school to help them learn school science), and how she helped the students to critically examine their eating and activity practices.

It was this second layer of coding that allowed us to dig into what Mrs. Hanson actually did. As we established relationships among our codes, we developed coding trees that shed light on Mrs. Hanson's practice. For example, one of our coding trees examined when Mrs. Hanson "expanded the curricular goals" either by adding assignments, materials, or the goals for the lesson that drew more from students' lived, cultural experiences as well as emphasized scientific practices. We traced out pathways for each of these, looking for patterns in how her expansions created or constrained opportunities to respond to science practices or to her students' lives. Another one of our coding trees examined classroom discourse for the presence of talk focused on students' funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992). When did students bring in their own cultural knowledge and experience? How was it supported by what Mrs. Hanson said and did, and by the structures afforded by her teaching practice (i.e., the curricular enactment, the materials available, her own dispositions)? We noted a common pattern emerging from both coding trees; Mrs. Hanson tended to rely upon tools (e.g., bar graphs, pedometers, a good research question, stories/narratives, PSA posters) to negotiate a place that was both responsive to science and to her students' lives. We viewed these as kinds of boundary objects (Cobb et al., 2003). It is important to note that we did not enter the data analysis looking for boundary objects. Rather, this second layer of coding, which involved looking for relationships among teaching practice and CRP outcomes, led us to notice the tools Mrs. Hanson used, and which ultimately led us to consider these tools specifically as what we term transformative boundary objects.

Our third layer of analysis, therefore, drew and expanded upon Cobb and his colleague's (2003) notion of boundary objects to analyze how these tools and cultural representations helped create "focal points around which interconnections between communities emerge," (p. 19) and, more important to our investigation, how these interconnections challenged

TABLE 1
Data Sources

Data Source	When	Explanation
Student artifacts	Throughout entire unit	Student workbooks and/or selected activities • Brainstorming and Planning an Investigation Worksheets (Unit 1) • Summing up worksheet (Unit 1) • Food and Exercise in Your Life student worksheet (Unit 1) • Self portrait planning worksheets (Unit 2) • Bite and write homework (Unit 2) • 24 hour intake worksheet (Unit 3) • Step and Write (Unit 3) • Choosing goals (Unit 3) • Summing up Unit worksheet (Unit 3) • How To Do It: The steps we take (Unit 4) • Making person changes/reducing risk for Type II diabetes homework (Unit 4) • Public Service Announcement (Unit 4) • Summing up Unit worksheet (Unit 4) • Personal Pledge Homework (Unit 5)
Initial student interview	Before the end of Unit 1	Eight students (four from two different sections) Interview took place at the beginning of Unit 1 *Focus of interview*: What does to “eat healthy” and “to be active” mean to you, and where have you learned about these things?
Midunit student interview	After goal setting	Eight students (four from two different sections) Interview took place after goal setting *Focus of interview*: These interviews probed why and how students decided on their goals and how they hope to achieve them, why they matter
Poststudent interview	Before the end of Unit 1	Eight students (four from two different sections) Interview took place after the end of the unit *Focus of interview*: Triumphs and challenges, connections between C3 and home and school
Teacher interview	End of the curriculum	Lesson adaptations, triumphs and challenges
Class observations	Across the curriculum	• Unit 1, Lesson 4 (7 days) • Unit 2, Lesson 9 (1 day) • Unit 3, Lessons 10 (2 days) and 12 (1 day) • Unit 4, Lesson 17 (2 days) • Unit 5, Lesson 18 • Field trip to University Health Center (2 days)

conventional practices in the science classroom. In other words, we were interested in the roles they played in the kind of revision and reconstruction of what it means to learn science in which students might engage in the process of developing a more critical consciousness. Buxton, Carlone, and Carlone (2005) similarly use the notion “boundary spanners” to investigate how students' Discourse and school Discourse were bridged. By analyzing these boundary objects, we were able to gain insight into how science learning with critical consciousness developed in Mrs. Hanson's classroom, where the students drew on experiences and practices from their every day lives to investigate and transform their understanding of dynamic equilibrium and their eating and activity practices.

In this paper, we make a distinction between students' everyday knowledge and practices, or their "home culture," and "school science." Students' daily food and activity practices are shaped by social, environmental, and biological factors (Calabrese Barton & Tan, 2009). By school science, we are referring to how science is traditionally taught in schools, where Western science is privileged and everyday practices are seen as incompatible with learning science (cf. Lee, 1999). It is the boundary between these two communities—home culture and school science—that we seek to elucidate ways of transformation brought about by transformative boundary objects.

FINDINGS

In this section, we illustrate Mrs. Hanson's pedagogical approach to teaching the C3 curriculum and what the approach afforded her students. We then show how her teaching practices were anchored in a set of transformative boundary objects. We further argue that the value of the transformative boundary objects resides in how they supported students in ways consistent in all three tenets of CRP, but especially the third one—learning science with a critical consciousness.

Looking More Closely at Mrs. Hanson's Teaching Practices

Mrs. Hanson was always prepared to teach her lessons and planned several weeks and months in advance to ensure that she covered everything that was demanded in the sixth-grade scope and sequence. Owing to time constraints, Mrs. Hanson initially planned to teach most, but not all, of the lessons in the C3 curriculum. She planned to teach C3 following the teaching of related body systems. Therefore, we were surprised when Mrs. Hanson's approach to teaching C3 involved expanding the lessons and curriculum to take several weeks longer than planned.

When we talked with Mrs. Hanson about her approaches to teaching C3, she explained that the C3 curriculum helped her students to think about how science relates to their own lives:

> I think that it [experiences with the C3 curriculum] really made them be able to think about how science relates to their own lives. And that's the part I think is the chunk that's missing from a lot of science curriculum. You know, fine but how does it apply to me? And so I mean, this had them analyze how much they moved and what they ate and where they ate and so I think that was, that was a great component of this. They had to focus on themselves and how do the science concepts which sometimes are out here for them, you know, how do I pull it in and apply it to myself. ... And it's not just an abstract idea that has no relationship to me as a student.

Mrs. Hanson signals a problem with much of school science—the disconnect between the science taught in schools and students' lives. Traditional school science does not take into account students' daily practices, let alone leverage them to help students better learn science. Mrs. Hanson's student-centered response captured in the quote above exemplifies what we observed in her teaching. While the learning goals for the curriculum involved students being able to use scientific evidence from their everyday lives to make healthful food and activity choices, Mrs. Hanson used those curricular moments to insist that her students' lives were worth studying. As she stated above, what was often "missing from a lot of science curriculum" is how "science relates" to students lives. In our analysis of Mrs. Hanson's approach to C3, however, what we saw was a pedagogical approach that did more than relate science to their lives. Her approach drew upon the cultural knowledge and practices of her students' lives as important dimensions to scientific meaning making in ways that fostered critical consciousness.

Creating Transformative Boundary Objects

What made Mrs. Hanson's approach to science teaching possible? Unlike traditional school science, we show how Mrs. Hanson's approach to teaching mattered not simply because she positioned the students' cultural knowledge and experiences as valuable, although we do think this is important. Rather, upon closer examination we noticed that Mrs. Hanson used "transformative boundary objects" in ways that allowed scientific sense making to be supported and informed by everyday experiences at the same time that it allowed the scientific ideas developed to be deeply contextualized and reconstructed. In other words, transformative boundary objects helped to create a context where students could both *bridge* and *transform* borders. We argue that Mrs. Hanson used transformative boundary objects to support the development of an intercultural exchange and critical consciousness because they supported what we believe to be (a) an *awareness* of and *trying on* of the norms and practices of science (CRP's goal #1 of academic success) and (b) the *legitimization* of experiences and practices from students' everyday lives outside of school that is *transformative* of the traditional discourses and practices of school science in a way that fostered critical consciousness (CRP's goals #2 and 3 of cultural competence and critical consciousness). In what follows, we provide four analytic narratives (bar graph, scientific research questions, nutrition labels, and PSAs) describing how Mrs. Hanson used transformative boundary objects in ways that were consistent with the goals of CRP. For a summary of these transformative boundary objects and their use in the lessons, see Table 2.

Bar Graph. In Lesson 12 in the C3 curriculum, the students were introduced to the idea that the food pyramid is based on scientific evidence on how to stay healthy and that students, likewise, can learn to make healthful food and activity choices based upon scientific principles and reasoning with evidence from their own lives. The lesson involved the class discussing how and why scientists set guidelines (such as MyPyramid, a Web site created by the U.S. Department of Agriculture on nutrition and the food pyramid) for healthful eating and activity based on scientific research and why it is important for youth to understand the role of scientific evidence in making sense of MyPyramid. The teacher then introduced the C3 curriculum's five recommended food intake goals that are derived from the MyPyramid guidelines that included servings of water, sweetened beverages, fruits and vegetables, fast foods, and packaged snacks and reviewed the scientific evidence upon which these recommendations are based. Finally, the students graphed their own serving intakes of the five aforementioned categories and prepared to set healthful goals.

How Mrs. Hanson Used the Bar Graph. Below, we describe the portion of the lesson where the students were reviewing and graphing their serving intakes. Mrs. Hanson asked the students to look at their 24-hour food logs, where they had collected data about the servings and amounts of what they had consumed, using the categories of water, sweetened beverages, fruits and vegetables, fast food, and snacks as proxies for healthful/unhealthful

TABLE 2
Boundary Objects

Boundary Object	Bridged Communities	Transformed Communities
Bar graphs	• Sanctioned student experiences: legitimized their lives as possible sources of data • Tool to represent data: showed differences between personal and scientifically recommended practices	• Provided opportunities to discuss social and environmental factors that influence personal food and activity practices (e.g., parents don't feel like cooking, taste, traveling, busy) • Tool to critically analyze practices: provided setting for applying knowledge to their lives • Created awareness of practices, created goals, worked toward goals
Science research question	• Created research questions based on students' interests • Used own knowledge about peer, family, and community practices to refine researchable questions • Examined language: science vs. lay	• Critiqued the role of science in society • Examined peer, family, and community food and activity practices
Nutrition labels	• Investigated foods at home and discussed in class • Analyzed and compared to scientific recommendations	• Tool to critically analyze practices: provided setting for applying knowledge to their lives • Led to changes in practices: student looked at nutrition labels of foods, which informed their food choices (e.g., ate less hot Cheetos, looked at serving sizes, smaller portions)
Public service announcements	• Way to express knowledge in scientific and cultural ways • Collected data on peer, family, and community practices	• New way of participating in science: creating product that takes into account both personal interests/values (forms of expression) and science practices (data collection, scientific evidence) • Empowered students to make changes • Educated others

eating habits. Mrs. Hanson focused her students on this task by using a line of questioning to guide their work that evoked both personal narrative and data specificity:

> How about fast food restaurants? In the last 24 hours how many times did you eat at a fast food restaurant? If you went once put a 1. If you went 4 times put a 4. If you went 0 times put a 0. Think about how many times a week you go. . . . you might be like oh yeah, last

> Saturday we were running around doing some shopping, we stopped at a fast food place for lunch. Or, we stopped and picked up a pizza. Or, whatever it might be. So think about in the last week. Maybe you stopped at McDonalds for breakfast this morning.[2]

Mrs. Hanson prompted students to think about their data, and how their data were informed by their contexts. She asked them to think about what they were doing in their daily lives and *how their food choices were dependent upon their practices* such as shopping or stopping by McDonalds for breakfast before school. This is an important point about Mrs. Hanson's teaching—she did not merely ask students for isolated bits of information on their food intake (which could be argued as precisely the characteristics of traditional scientific "data points"), she framed her questions around the larger cultural contexts of her students—when choices of food and eating are enmeshed with other salient areas of their lives. Students talked about how they stopped to get fast food for breakfast because it was quick and easy (they or their parents did not have time to make breakfast). They discussed how fast food options were close to school and more readily available than fresh foods. In short, Mrs. Hanson and the students situated the conversation of where and why they have access to certain foods within the context of their everyday lives and students began to question why they engaged in certain food and activity practices.

After students talked about their experiences and created graphical representations of their food/drink data, Mrs. Hanson asked them what they noticed about their fruit-and-vegetable-consumption graphed data versus the recommended amounts:

Mrs. Hanson: When you graphed your amount, compared to the recommended amount, what did you notice?
Student: Mine was more than the recommended amount.
Mrs. Hanson: OK, who has something different for that one?

Several students then raised their hands and called out their answers.

Mrs. Hanson: What'd you find?
Jason: Mine was a lot lower.
Mrs. Hanson: Yours was a lot lower. But how much lower?
Jason: Um, mine was 0 instead of 5.
Mrs. Hanson: Right, he doesn't even have a bar!
Whole class: Ahhh! Wow!
Mrs. Hanson: Because he had no fruits and vegetables over the last 24 hours. We're not making a judgment, we are just looking at information.

Mrs. Hanson pushed her students to be specific when discussing their data; she wanted them to use numbers. She called attention to Jason's response when he presented specific data to answer her question: "Mine was 0 instead of 5." At the same time, she purposefully used the content of the students' own experiences to engage them in trying out this scientific practice of precision in communicating data. Furthermore, she reminded the students that the point of the task was not to critique others' food choices, but to make sense of the data.

[2] Students kept track of the amount of water, sweetened beverages, fruits and vegetables, and packaged snacks they ate in a day. The amount of fast food was measured by week.

Mrs. Hanson then explained to the students the value of the bar graph:

> The bar graph is a great visual tool for us to compare what the recommended amounts are to what we actually do in our daily lives. This will help us as we are choosing a goal. When you look back at the three graphs you just did, does anything really jump out at you and you say, whoah! I'm really off here? I'm not even close to what the recommended amount is for something?

While the curriculum called for the students to compare their food habits to recommended amounts, how Mrs. Hanson led the discussion was particularly important. As the lesson progressed, the class discussed why some students found differences between their food and activity practices and the recommended practices. Instead of simply telling the students the recommended food and activity guidelines using the authority of science to justify them as "right" and judging students according to the guidelines, Mrs. Hanson asked her students to draw upon their own experiences to both explain and to be critical of the recommended guidelines. For example, she asked students, "Why do you think that first box says 'eat less frequently at fast food establishments. Aim for no more than three times a week?"' After a few students called out responses like "You don't want to get sick," Mrs. Hanson redirected the conversation with a more pointed question:

Mrs. Hanson: Why do you think they did not say don't eat at fast food restaurants at all? What do you do? Would that be a realistic goal? Would that be realistic?
Student: Yah.
Student: No.
Mrs. Hanson: Yeah. If I, if they said you cannot eat, aim for 0 times, would that be a realistic goal?
Students: No.
Mrs. Hanson: Nooo. Why not? Why do a lot of us eat, once, twice, three times a week at fast food places?

What ensued was a discussion where students called out examples from their own experiences, which provided both a rationale for their practices as well as a critical analysis of whether the recommended guideline was realistic for their lives.

Student 1: My parents don't feel like cooking.
Mrs. Hanson: Yah your folks might be tired. Convenience, yah.
Student 2: I'm tired of cooking let's go out.
Mrs. Hanson: Yah, what else? What else?
Student 3: It's good.
Mrs. Hanson: What else? ... Why do you make those choices? There are reasons they are on lots of corners in lots of cities!
Student 6: Because some people are traveling they want something that is quick.
Mrs. Hanson: Yah, a lot of us are busy, just plain busy, and we are on the road. How many of you have eaten fast food in the car? Sure?
Student 7: When we went to my grandmother's house.
Mrs. Hanson: Yah you are going somewhere. A lot of us in the US eat our meals in the car. We are busy and we are hungry and we want to eat.

Mrs. Hanson's questions were pointed, and she used them to draw attention both to scientific ideas and the reasoning processes youth used to make sense of these scientific ideas. Her questions helped students examine why they held certain food and activity practices, as was evidenced in how students made statements showing an awareness of how their food choices are situated in their family's everyday practices, such as "My parents don't feel like cooking" and "people are traveling they want something that is quick." This exchange around everyday practices helped push students' understanding of how food practices are situated in a complex food system that takes a particular form in the low-income urban community. At the same time, it pushed them to further consider the federal guidelines regarding food choices, deepening their understanding and helping them develop a critical consciousness about how different their eating habits were compared to the federal guidelines and whether the federal guidelines were useful for them to follow, or as Mrs. Hanson puts it, "realistic"?

At the end of the class period, the following exchange occurred:

Mrs. Hanson: From what you learned about your current eating from analyzing your 24 hour food intake [creating bar graphs] and what you just wrote about why healthful eating is important, think about the goal that you want to choose.
Marcus: It's importaant to choose something that is practical—
Mrs. Hanson: and realistic
Marcus: and realistic for *your life*.
Mrs. Hanson: Alright. You're going to choose a goal right now. And as Marcus just said, the goal needs to be *practical* and *realistic*.

After the students collected and analyzed the data on their own eating practices and learned about the scientific evidence for the C3 goals, they selected specific goals for themselves. While Mrs. Hanson wanted the students to apply scientific knowledge and practices to their everyday lives, like choosing goals based on scientific evidence for healthful eating practices, she also positioned their own everyday practices as an essential element to consider. As Marcus stated and Mrs. Hanson reiterated, the goals needed to be *practical* and *realistic, for your life*. The two types of knowledge and practices were used to challenge and enhance their understanding of both scientific culture and everyday knowledge and practices. Through providing opportunities for students to critique science and their everyday knowledge and practices, Mrs. Hanson helped empower students to make educated decisions that fit their lives. It is important to note that we interpret such action not as using science to "correct" everyday knowledge and practice, but rather as putting the two kinds of knowledge and experiences in critical dialogue. This kind of critical dialogue, we feel, is the crux of critical consciousness because it supported students in using their everyday experiences to understand the power and the limitations of the scientific rationale behind recommended everyday food choices as outlined in the food pyramid.

The Bar Graph as a Transformative Boundary Object. Mrs. Hanson's actions used the bar graph in such a way that it (a) reified students' food practices, (b) fostered dialog about the ways in which food choices are deeply contextual despite the abstract nature of the food pyramid, and (c) focused attention on the importance of making scientific sense out of practices of differing epistemological origins.

The bar graph served as a physical representation of the students' food intake; a manifestation of what was available to them in their homes and communities and how they navigated that on a daily basis. In as much, it contained both a scientific interpretation of their food intake and a recognition of their food practices. It provided the point of interconnection essential for a critical examination of food practices in light of the scientific guidelines for food intake (e.g., food pyramid) and the food system itself (e.g., what was available in their homes and communities).

This representation supported youth in trying out and developing some proficiency in learning how to quantify data and how to build evidence-based claims, two important scientific practices necessary for academic success in science. At the same time, the bar graph also was used to contextualize these practices within students' experiences in the food system. It was just as important in the conversation for students to notice important patterns and trends in their locations in the food system, even if these oppose the food guidelines, because the goal of the collective analysis was not to "mak[e] a judgment" but to be practical and reasonable.

Mrs. Hanson used the graph to foster dialog across scientific guidelines and students' experiences in ways that promoted cultural competence and critical consciousness. She used scientific knowledge and practices (data collection and analysis) to help students critically examine their home-based, everyday practices through the graphic representation. Through collecting and graphing data from their lives, students had opportunities to become aware of their food consumption practices and were asked to consider ways that they might make changes that incorporated their scientific thinking and their home-based practices. In an interview, two male students talked about its impact on them.

Interviewer:	Did you realize that you were drinking so much pop before?
Trey:	No
Interviewer:	Yeah, so was this the first time you realized, because you had to keep track?
Trey:	Once we started doing it, that's when I started noticing.
Interviewer:	Yeah. What about you, John? Did you know that you drank a lot of pop?
John:	I knew I was drinking a lot of pop but I didn't know how many ounces that I was drinking a day. So that really helped me, what we did in C3 [collecting, graphing and critiquing food and activity practices].

The students went on to talk about how they made changes in their lives; they set goals to drink less soda (pop) and met their goals by drinking more water, only drinking a half glass of soda instead of a full glass. Both students went from drinking 48 and 40 ounces of sweetened beverages a day, respectively, to 8 ounces or less. Through examining the context of their food practices—how and why they consumed what they did—they realized that they used to stop by the local dollar store after school each day to buy soda. Now, they saved their money instead.

While students always bring their everyday knowledge into the classroom, it is not often validated and leveraged in ways that foster deeper and more critical engagement with science. Mrs. Hanson's use of graphs blurred the boundary that often exists in science classrooms between science and the everyday knowledge and practices, as the everyday experiences became essential to interpreting the graph and the evidence-based scientific eating guidelines. Students were asked to use their graphs to set realistic and practical goals that were closer approximations of healthful eating given their current practices. They critically examined their practices and applied their learning to their lives by enacting change based on their science learning and their values and life situations. Thus, it was not simply the tool that brought students' outside of school and school science communities together, but how Mrs. Hanson and her students used the tool that turned it into a transformative boundary object that fostered science learning with a critical consciousness. The bar graph crystallized for students how their everyday food practices were important data points in constructing a relevant school science narrative, and that the insights from that school science narrative serve to inform them about real and realistic changes they can make in their everyday food choices. Students' food choices and practices in their lives outside of school, as well as their school science knowledge and practices, were drawn upon and transformed.

Scientific Research Question. In the final lesson of the first unit of the C3 curriculum, students were asked to plan and carry out a research project related to the students' interests in food and activity choices. The 1-day lesson focused on teaching students how to investigate the complex food environment where they make their daily choices. Mrs. Hanson adapted the lesson and extended it to *seven* class days to support students in learning how to develop scientific research questions that were scientifically rigorous and locally meaningful.

How Mrs. Hanson Used the Scientific Research Questions. Mrs. Hanson began the science research question lessons by talking with her students about the importance of good, scientific research questions. In this opening conversation, she focused heavily on using the "what, when, where, how, and why" framework to testing and refining good researchable questions. However, embedded in how she took up the five question framework was a focus on the importance of the contexts of students' lives. After presenting this framework, she shared an initial example about cereal commercials on the Cartoon Network. She stated,

> I'm going to come up with a big question that I want an answer to.... I want to know *how many* and *what brands* of cereal commercials are on the Cartoon Network, that's such a station right? Saturday morning from 7 am to 9 am. This is my big question. In other words, I'm really interested in seeing how companies target kids who watch commercials. And I'm going to go to a place where I'd find commercials for kids, the Cartoon Network, and I want to know how many cereal commercials do they show on the Cartoon Network, on Saturday morning from 7 am to 9 am and I want to know the brand of cereal, cereals are advertised in those two hours. That would be my big question for example. Okay? So, I'm specific. I know who I'm targeting, I'm looking at cereal commercials for kids.

Mrs. Hanson then, with the help of her students, analytically picked apart her example by focusing on who (kids), what (cereal commercials), when (Saturday from 7–9 am), and where (Cartoon Network) she was interested in researching. This led to a conversation initiated by the students on whether the channel Mrs. Hanson chose to investigate was appropriate for her topic.

After her initial example, Mrs. Hanson divided the students up into groups and asked the groups to come up with research questions. Then she asked each group to come up and put their questions on the overhead so the whole class could critique each others' questions. Reading a student's question about hamburgers ("How many calories and fat are in McDonalds, Burger King, and Wendy's hamburgers?"), Mrs. Hanson engaged her students in peer review. While focusing on the what, Mrs. Hanson recognized and emphasized the students' everyday knowledge and practices (e.g., knowledge of different types of hamburgers at fast food restaurants) as integral to doing good scientific work:

Mrs. Hanson: Why would that be a good question or a not so great question?
Jamal: We need more information.
Mrs. Hanson: What more information do we need?
Sarah: What type of hamburger.
Mrs. Hanson: Yeah. We'd need to make sure the hamburgers are what?
Sam: Hamburgers!
Mrs. Hanson: Are identical. In other words, I can't do a hamburger from McDonalds, a single hamburger, and a cheeseburger from Wendy's and a chicken

sandwich from Burger King. I would have to make sure that the things I'm comparing are exactly the same. . . . . Okay? Is everybody kind of clear on that? Why would it be important to make sure that they're are the same? Why can't I do a Whopper here and a Big Mac here and I have no idea what deal Wendy's has. What do they call their thing?

Josh: A Baconator.

Mrs. Hanson: A Baconator. Why couldn't I do those? Why couldn't I do those three things?

Rachel: Cause they'll have different things.

Mrs. Hanson: They'll be different. They'd be different sizes, they'll have different things on them. One will have bacon, one will have this sauce. So when I'm comparing, I need to keep the things as similar or as the same as possible.

Mrs. Hanson drew on students' knowledge of fast food offerings to help them think about specific research questions. She continually reiterated the importance of specific research questions throughout the lesson:

> Again, see how we need to be specific in terms of how we're designing our question. Okay, we're getting really good at this. Okay so again, we know what they kind of want here in their questions, but we're just missing some specifics. But we could fix their question by adding specifics. Who are you asking, what type of pizza, and what do you mean by taste good? Remember we have to avoid generalizing words in science. What do you mean by taste good? What you think tastes good, what you think tastes good, what you think tastes good, what I think tastes good, we might have different meanings.

In pointing out the importance of *specific* research questions, Mrs. Hanson emphasized the importance of language, and at the same time acknowledged the cultural inferences students might make. Here, Mrs. Hanson brought up how the word "good" can hold multiple meanings, depending on the person or context. Thus, the students had to be careful with the language they used in their questions because they might mean something different in "scientific language" and everyday language, a point that Moje and her colleagues have reported on in their work (Moje et al., 2001). Mrs. Hanson helped the students to distinguish between the norms of everyday language (home) and scientific language (school) and practice being "specific."

The class spent 3 days working on researchable questions. After the second day of working on research questions, two students who were interested in investigating the nutritional value of fast food went to McDonalds to get a nutrition guide, asked the manager for a nutritional guide, and brought it into class. Mrs. Hanson recognized their effort by giving them time to show and discuss the guide with the class and suggested that the guide could give the students ideas for their research question. In this case, the students actually brought a physical artifact that they obtained from somewhere they frequented in their daily lives outside of school into school to help them think about research questions that investigated their eating practices, Mrs. Hanson showcased it, and students used it to examine and critique their own eating practices and the practices of fast food restaurants (e.g., adding sugar to hamburgers).

The Scientific Research Question as a Transformative Boundary Object. Mrs. Hanson used the scientific research questions as a transformative boundary object in the way that she incorporated and supported students in leveraging their everyday knowledge and practices (i.e., television channels they watch, foods they eat) in designing good research questions.

She urged the students to draw from their everyday knowledge and resources to help students to refine their questions by making them more specific. Mrs. Hanson simultaneously fostered her students' development of scientific practices and cultural competence; she used scientific research questions as a transformative boundary object so students could learn about how to formulate a research question that was situated in their everyday lives and interests.

By coming up with questions related to their lives and investigating their questions, the students also were able to critique their "social order" (Ladson-Billings, 1995a); they were able to critique how and why they, their peers, and their family members made food and activity choices. Students questioned how social factors influenced food practices (i.e., buying certain pizza because of how they are advertised, amount of fat and calories in McDonald's hamburgers) and why people hold food and activity practices. One student came up to one of the researchers during class to talk about her research question.

Sandra:	You know how I was talking about the Pizza Hut P'zone. . . How they have like over one pound of stuff in it?
Researcher:	Mm hm.
Sandra:	I'm gonna do a test on that!
Researcher:	You're gonna do a test on the pizza to see if it's over a pound?
Sandra:	The P'zone. Yep. Cause they said it's over a pound. If I buy two of them and they're different weights. Yeah.

Sandra talked about how a television commercial claimed that a pizza had over a pound of toppings on it as a technique for getting people to buy their product. She recognized that people might buy the pizza because of the commercial's claims. She developed a research question and plan to investigate the claim. It is important to note that prior to this lesson, the students had spent 2 days discussing how commercials influenced the products that they bought, and these conversations continued throughout the unit. The process of developing a research question gave students an awareness of their food and activity practices, and as seen in this case Sandra's research question provided her with the starting point from which she could investigate how her social environment (television) influenced her food choices.

The form and function of the scientific research question in Mrs. Hanson's teaching practice represented a way of interacting with and understanding the world central to the scientific enterprise. However, the students contributed to this scientific enterprise with the food practices of their homes and communities—where and how they get their food information, what sense they make of it, what they care about, and so on. The students used their own knowledge about peer, family, and community practices to refine researchable questions and to focus on the language of science and the ways in which it informs, and indeed is a part of, how one might navigate the food system on a daily basis. The research questions provided a common structure to support academic development and cultural competence simultaneously.

However, it was not simply that the research questions spanned students' worlds with that of school science, but that Mrs. Hanson used research questions to transform boundaries between science and everyday culture in ways that helped develop critical consciousness that mattered. She used the process of developing a specific, fair-test, research question grounded in students' everyday knowledge about their food choices and lifestyles to help students make connections to their everyday lives, leverage their knowledge and practices, and critically analyze how social and environmental practices influence their behaviors.

Nutrition Labels. Mrs. Hanson also used nutrition labels as a transformative boundary object to help students learn about healthful eating practices.

How Mrs. Hanson Used Nutrition Labels. As part of the curriculum, the students learned how to read nutrition labels using nutrition label examples provided in the student guide. Mrs. Hanson added a homework assignment that was not part of the C3 curriculum where she asked the students to go home and examine a real food item's nutrition label from their refrigerator or cupboard. In her interview, Mrs. Hanson recounted:

> And I said pick something in the refrigerator, the freezer or the cupboard. I just made up a little sheet and I said how many servings is in it, how much sugar per serving, how much sodium per serving, how much fat per serving. So they were all coming in with their, well, our macaroni and cheese box and, wow, my cereal, do you know, Ms. Hanson, I'm only supposed to have this much cereal and I put a lot more in that bowl. So again, it got them talking about how it related specifically to them.

Mrs. Hanson initially provided students with the opportunity to bridge home and school by asking them to collect data from food products from their homes and bring the data into the science classroom. This is important because asking the students to examine the nutrition labels of foods they actually ate at home provided a personally relevant context for the students, unlike the decontextualized nutrition labels provided as part of the curriculum, connecting and transforming boundaries between home and school. As with the bar graph and research questions, Mrs. Hanson used nutrition labels as a transformative boundary object that allowed students to draw on and critique data from their lives. They used knowledge they learned in the C3 curriculum about recommended amounts of daily fat and sugar intake and applied them to the foods that they ate. Students then became aware of and critiqued the nutritional value of the foods they actually ate. Mrs. Hanson recounted some of students' discoveries about food from reading the nutrition label:

> [student telling Mrs. Hanson] My cereal, do you know, Ms. Hanson, I'm only supposed to have this much cereal and I put a lot more in that bowl. .. . And I know a lot of kids went home and talked about, with their family with going to fast food places because they were telling me, you know, my mom ordered the such and such and I said, well, you know, mom, there's a lot of fat in that. Why don't you just get the small fry, you know.

The students also discovered that some juices contain a lot of sugar. "They [students] were like ooh, there's a lot of sugar. I couldn't believe it, you know, how much sugar." As Mrs. Hanson explained, she wanted her students to develop an awareness of what they ate and wanted the content of the lesson to come from their experiences.

Through this experience, the students were able to practice their understanding of science: reading nutrition labels (examining serving sizes, comparing ingredients and recommended amounts of calories, fat, sugar, and so on). Furthermore, they were able to apply their knowledge to critique food choices. Mrs. Hanson recalled,

> I remember specifically macaroni and cheese because somebody was like why do they have to put all that sugar in macaroni and cheese? I'm like, why, why do they? So I mean, it really got them. They were like, I didn't know there was so much sugar in macaroni and cheese. It really started the dialogue, I think, in terms of who thought. They never thought they'd find so much sugar in something like macaroni and cheese.

However, what stood out for us was how the nutrition labels served as proxies for much deeper and more critical dialog about their food choices, the food system that facilitates such choices, and how scientific guidelines are communicated within cultural contexts. In other words, nutritional labels became powerful—and ongoing—transformative boundary objects through Mrs. Hanson's pedagogy. They became artifacts that both established and destabilized the boundaries between what it means to make healthful choices and how you understand those choices within the broader food system, even after the lesson on food labels was completed.

Take, for example, the case of the Cheetos food label. Mrs. Hanson mentioned that hot Cheetos were one of the students' favorite snacks to eat. She always saw students eating hot Cheetos or empty hot Cheetos bags around the school. The students decided to examine the ingredients in hot Cheetos and found that they did not contain any cheese:

> Mrs. Hanson: Cause we had a big discussion one day about how there's no cheese in Cheetos. And they're [students] like I'm gonna check the package. I said go check the package. And they come in and they're like there's no cheese. How can they say? Remember, we talked about advertising. You know, how do they get away with that? I mean, they were just appalled.

During the lesson on food labels, several students questioned how hot Cheetos could advertise being "cheesy" when they did not contain cheese. The students were interested in investigating the ingredients of their favorite snack, hot Cheetos, and Mrs. Hanson not only encouraged this by telling students to examine the nutrition labels, but she sanctioned their interests by holding a classroom discussion about it even after the initial lesson was over. The students were taking initiative by applying what they were learning in school to their lives; they were empowered to learn more and take action by applying what they learned to their own eating practices.

As the curriculum progressed, Mrs. Hanson reported to her class that she noticed fewer students eating hot Cheetos and found less evidence of hot Cheetos (i.e., empty bags) around the school. Even in our post-C3 interviews, several of the students mentioned that what they learned about Cheetos as a packaged snack was important to their goal setting. When reflecting on his goals for food choices, one student, Ryan, mentioned that his main goal was to "eat fewer packaged snacks." He was eating two to three packaged snacks a day. "It was like Cheez-its[3] [sic] and stuff like that. . . " and he realized that he ate them "Cuz that was like the only snack we really had [at home]." However, Ryan became aware that Cheetos contained sugar and fat, not only possibly making him gain weight but contributing to the potential of developing type 2 diabetes. Because he could not change the snacks at home, he ended up putting them in place way up high in the kitchen cabinets that was not easy for him to reach. Furthermore, he challenged his sister to a contest to see who could stop eating packaged snacks for the longest period of time. He not only took the information he learned in class and used it to change his daily eating practices, but he also shared his new knowledge with his sister.

We found several other examples where students used their knowledge of nutrition labels to help them investigate the ingredients in their foods, to think harder about the food systems they navigate on a daily basis, and to set better food choice goals. Students talked about the nutrition labels provided by McDonalds and other fast food restaurants, and food labels were a dominant theme in the PSAs they generated at the end of the unit—messages

[3] While the student said "Cheez-its" in this interview, he later went on to talk how they were hot, which leads us to believe he was referring to hot Cheetos, a favorite snack of many of the students.

intended to educate their peers and family members about dynamic equilibrium and the human body.

Nutrition Labels as Transformative Boundary Objects. Mrs. Hanson used nutrition labels to bridge students' home and school communities, bringing them in dialog with each other. Examining nutrition labels of foods students regularly ate provided students with personally relevant contexts within which to learn science. In bringing together students' daily food practices and science, students also challenged the social factors, such as marketing and advertising the food availability in their neighborhoods and homes. In many cases, the students changed their eating practices due to the knowledge they gained from their investigations. Students continued to examine the nutrition labels of food products they ate after the homework assignment and lesson were completed. Perhaps they may have continued this practice even if they had not completed the homework assignment analyzing food from their home, but as Mrs. Hanson said, "it really started a dialogue I think, in terms of who thought. They never thought they'd find so much sugar in something like macaroni and cheese." The way Mrs. Hanson used nutrition labels made them transformative boundary objects because they connected home and school science practices in ways that deepened and changed their understanding of both science and their daily eating practices.

Public Service Announcements. Mrs. Hanson provided flexibility in some of the lessons that allowed for students to bring into the classroom and use their own cultural representations; representations and forms of expression that are often missing from traditional school science. By cultural representations, we mean that the students were able to express themselves in ways that are meaningful to them and that they use in their lives outside of school (home worlds). These expressions may not often be allowed or lauded in the science classroom, such as comics and smoothie recipes that we describe here. In one of the lessons, the students were asked to create a PSA to share with their peers, family, and community about the scientific reasons why certain food and activity choices lead to better health. The food and activity choices included eating less frequently at fast food establishments, eating fewer packaged snacks, drinking no more than 8 ounces of sweetened beverages a day, walking at least 10,000 steps a day, eating at least four cups of fruits and vegetables a day, and drinking at least 8 ounces of water a day. The students were expected to provide three pieces of scientific evidence that supported their choice for their PSA. They were also charged with coming up with interesting ways to get their message across.

One student, Gala, created a poster, "Packaged snacks eated [sic] on Wednesdays and Tuesdays," for her PSA. Her poster included six different sections:

1. A table that showed how many packaged snacks she and her friends ate on Tuesday and Wednesday.
2. A graph that represented the same data as above.
3. A did you know bubble: "did you know that most packages [sic] snacks can lead to obseasity [sic] or other unhealthy problems. Some can also make your teeth rot. You may say well we se [sic] can just lose it later. But its [sic] a lot harder to get back in shape later and you could get type 2 diabetes which is makes it even harder.
4. A cartoon that captured some of the same ideas (see Figure 1): "unfortunately this is Mrs. Stics grave. She ignored exirisize [sic] and died of obeasity [sic]."
5. Tips on what you could do to stay healthy: "walk 10,000 steps a day, eat fewer packaged snacks, drink more water instead of sweetened beverages, play or work outside instead of being a couch potato. Like they say, an apple a day will keep the doctor away . . . ."

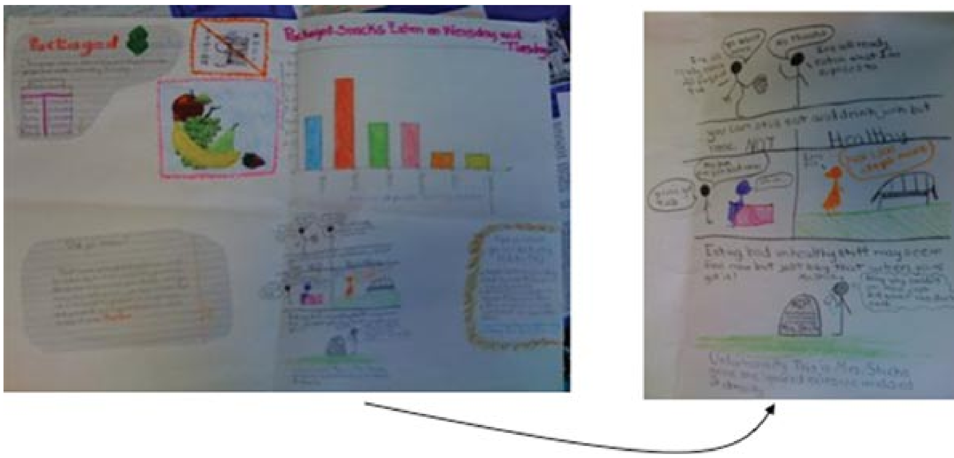

Figure 1. Gala's PSA poster. [Color figure can be viewed in the online issue, which is available at wileyonlinelibrary.com.]

In Gala's PSA, she personalized the poster by creating a cartoon, taking a serious issue and using humor to get her point across. Gala merged cultural representations with scientific representations. She included data she had collected on her friends about how many packaged snacks they ate over the course of 2 days to make her point that people ate more packaged snacks a day than recommended and provided suggestions for changing food and activity practices that were grounded in scientific evidence. In Section 3 of her poster Gala writes, "You may say well we se [sic] can just lose it later." She challenged an excuse that people often give for putting something off, such as exercising and eating healthfully. In her fifth section, she reiterated the idea that people should choose to "play or work outside instead of being a couch potato." Thus, she challenged what were sometimes life norms for some people and called on them to change their practices.

Similar to Gala, another student, Kim, provided recommendations for *how* people could meet the recommended goals for food and activity practices. Kim chose to make a PSA about the goal of eating at least four cups of fruits and vegetables a day. Along with providing scientific information about why this should be a goal, her poster contained recipes that she made up to help make it easier for people to eat more fruit as part of their diet. In an interview, Kim explained,

> I put there's like a whole bunch of ways that you can, that you can have four cups a day. And I put you can mix your fruit in a blender or you could put your fruits in a juicer. And then like on the sides put different, different like ideas for how you can like make your fruit—juices or smoothies or something. .. . I put recipes and I got them off the internet so then people would know how to just make this, like you can get up in the morning and just, or you can like have just a little activity, like you can have like a party or something and you can just have like all these little fruit juices and it can be like fun and it can be tasteful.

Kim created a poster that not only educated people about healthful eating habits but also provided people with suggestions for how to meet the recommended dietary intake of fruits. She included the scientific evidence because, as she said, it "would make like people like wanta like really think about it or like really put it in their heads like try and do it or something." In other words, she believed that the scientific evidence provided the motivation for people to enact healthful eating habits. Along with the scientific evidence for why people should eat four cups of fruits and vegetables a day, Kim also included resources that would allow them to achieve that goal so that meeting the recommended amount of fruits per day would be "fun" and "tasteful." She recognized that people may need help in finding ways to meet the recommended intake of fruits and vegetables and that food needs to taste good in order for people to eat it. Kim drew on her understanding of why people may not eat the recommended amount of fruits a day to provide some suggestions for how to get more fruits in one's diet.

After the students completed their PSAs, they were excited to share them with others. In one interview, a student said,

> This poster was like my main thing, like I really was liking this poster and so I would make another poster so like I would have this one for school and then I would have this one for out in the public. Then I can go to the community center and then like I can like have this idea and then we can like make other posters and then we can put them around the city and then it can be like outreach.

PSAs as a Transformative Boundary Object. Mrs. Hanson used the PSAs as a transformative boundary object in that they created a context where the students could draw on their cultural representations to learn, explain, and push their understandings of science and how it related to their lives. The students were able to make connections to their lives by collecting data from their lives and using cartoons and slogans to support their position. In their PSAs, the students critiqued food and activity practices (e.g., Gala's table and graph of her own and her friends' food practices) and gained more experience with science practices such as data collection and representation. Through creating their PSAs, the students questioned their own, their peers, and their families eating and activity practices and *why* they held these practices. They were able to leverage their knowledge of their communities' practices, including rationales for why they may have difficulties meeting recommended food and activity guidelines to create their PSAs. Furthermore, creating PSAs not only allowed the students to synthesize what they had learned about healthful eating and activity practices and how they impact their bodies, but it empowered them to share what they learned with others in their classes, schools, and communities.

DISCUSSION: TRANSFORMATIVE BOUNDARY OBJECTS AND CRP

Research has repeatedly shown that the everyday knowledge, experiences, and interests of students are often not valued or privileged in school science (e.g., Carlone, Haun-Frank, & Webb, 2011). Mrs. Hanson's teaching worked against these normative practices. We argue that Mrs. Hanson used typical science and everyday tools in ways that brought together, coordinated, and at times transformed the students' home communities (as represented by student actions in their lives at home) and the community of school science (as represented by Mrs. Hanson's pedagogy and classroom discourse). These tools, which we refer to as transformative boundary objects, helped to increase awareness of personal and community food and activity choices, provided opportunities to collect and analyze data, and legitimized the use of everyday experiences as a valid source of scientific data. Students were able to use data collected from their lives outside of school in their school activities to learn science in ways that transformed school science into a place where their own cultural resources and everyday lives were privileged. Mrs. Hanson used these transformative boundary objects to bridge and transform traditional school and home boundaries in ways consistent with Ladson-Billings tenets of CRP to

- encourage an *awareness* of and *trying on* of the norms and practices of science ("supporting academic success");

- legitimize students' everyday values, discourses, practices, and knowledge in ways that is transformative of the traditional discourses and practices of school science ("supporting cultural competence"); and
- help develop critical consciousness of food and activity practices in their lives and communities and how society influences these systems that empower students to make educated decisions based on their life situation ("supporting critical consciousness").

In strategically utilizing these transformative boundary objects, Mrs. Hanson's teaching practice was also transformed. As a science teacher and, therefore, the representative authority figure of school science, Mrs. Hanson reframed for her students what it means to engage in school science in her classroom. She actively recruited students' funds of knowledge while concurrently pushing them to think critically and engage meticulously in scientific practices. In so doing, Mrs. Hanson and her students redefined, for their science classroom, what and whose knowledge and experiences were sanctioned as legitimate and scientific, what the process of scientific inquiry could look like with regard to the roles students took up, what tools and resources could be used, and what the final learning outcomes and products could look like. Not only were the worlds of school science and students' everyday lives intimately connected by these transformative boundary objects, but the texts of school science expanded to include not only canonical science knowledge but also scientific data points from students' lived experiences. Simultaneously, scientific meaning actively permeated students' daily decisions about lifestyle choices surrounding food and exercise. During these lessons, with the help of the transformative boundary objects, Mrs. Hanson's students were both "living science" in their everyday lives as well as "critically investigating life through science" in their science class.

We stated earlier that boundary objects do not bridge communities by themselves. Rather, they bridge communities through how they are taken up and flexibly used by members of the communities they span (Trompette & Vinck, 2009). Mrs. Hanson's teaching practice included building and expanding connections between students' experiences and practices (home) as a part of learning science (school). While "boundary objects constitute focal points around which interconnections between communities emerge" (Cobb et al., 2003, p. 19), we argue that in Mrs. Hanson's case, her use of boundary objects was transformative for they served as much more than "focal points for such interconnections" (p. 19). There were sustained effects beyond the classroom science lessons that rippled through the two communities of students' everyday lives and school science and transformed the nature of the boundaries between these worlds. The research questions, nutrition labels, and bar graphs acted as transformative boundary objects that legitimized their lives as a valid source of data while they increased student awareness of their food and activity choices and provided them with means to collect and analyze data. For example, Mrs. Hanson used the bar graphs to encourage students to be specific with their data from home as she helped them to "try out" the norms and practices of science. Students were able to use data collected from their lives outside of school in their school activities to learn science in ways that transformed school science into a place where their own cultural resources and everyday lives were privileged.

Current literature on boundary objects neglects to take into account the transformative *iterations* that boundary objects make possible. The emergent teaching practices and subsequent engagement by students supported new forms of knowledge and practice in the science classroom that took place over time, and that advanced both worlds of home and school science. In our study, these moments of transformation appeared to build on each other, further destabilizing the boundaries between home and school science.

Mrs. Hanson used transformative boundary objects to leverage and legitimize students' cultural practices regarding food choices to transform the school science into something that was culturally relevant. Mrs. Hanson situated her students' data analysis alongside the cultural practices of families in their community (i.e., "If you eat McDonalds for breakfast each day"), an uncommon practice in traditional science classrooms. The way in which she engaged students with transformative boundary objects, through contextualization and how and why questions allowed them to engage in critical dialog on the role of science in making healthful decisions in their lives. The students questioned and challenged how aspects of their physical and social environment influenced their eating and activity choices (e.g., choosing realistic goals by taking into account social and environmental factors such as access to processed vs. fresh foods). Mrs. Hanson used transformative boundary objects to bring the culture and practices of science into communication with the knowledge and practices of students' lives, allowing for intercultural exchange that provided students with the skills and knowledge necessary to make informed decisions about their practices.

Learning science and developing the practices of science were important goals that Mrs. Hanson held for her students (academic success). She consistently and explicitly used the C3 lessons to engage students in metalevel conversations about the design of experiments, the collection and analysis of data, and the representation of findings. However, she did so in a way that positioned students' experiences as valuable and worthwhile of study (cultural competence). Because teachers hold positions of authority in the classroom, they play an important role in sanctioning students' everyday experiences. Thus, the teachers' practices must provide students with opportunities to connect to and leverage their everyday experiences and practices. While graphs, research questions, nutrition labels, and PSAs were important in helping students make connections between science and their lives, it was not these objects in particular which matter most, but *how Mrs. Hanson used them* which allowed the members of her classroom community to take them up as transformative boundary objects. For example, the use of bar graphs gave the students a consciousness of their food and activity choices. Students used graphs to represent data where they compared their food and activity practices to recommended practices. Discussions of the recommended food and activity guidelines were grounded in students' experiences where students could wrestle with why the guidelines were created and why certain guidelines were easier or more difficult for them to meet. They drew on their knowledge of their social and environmental factors that influenced their practices. At the same time, Mrs. Hanson used the graphing exercise to help students think about accuracy in their data collection and representation and how the data could give insight into the energy balance (dynamic equilibrium). The graphing exercise was set up in a way that positioned the students as authorities and their experiences as valuable. Students were able to use their own personal experiences to push on the science and vice versa.

In their review of studies of CRP in classroom-based research, Morrison and her colleagues' (2008) found that one way in which teachers fostered their students' development of critical consciousness was by sharing power in the classroom. In his conceptualization of sociotransformative constructivism (STC), which we argue is a form of CRP, Rodriguez (1998) argued that power is central to STC because "power is the currency of social change" (p. 599). When Mrs. Hanson created an assignment asking students to examine the nutrition labels from food products at home, she also created a power-sharing opportunity with her students. Focusing on students' chosen nutritional labels from home allowed the students to make explicit connections to their lives outside of school by collecting relevant home-based data and bringing it back to school while also teaching them about ingredients, calculating calories, looking at serving portions, and comparing them to recommended nutrition guidelines. Again, this transformed the language of science (home data points are valuable and important in science) and elevated students' epistemic authority by positioning them as experts in this science conversation about understanding nutritional labels. We found that Mrs. Hanson, through sanctioning and drawing on students' everyday knowledge and practices, distributed the power in the classroom in ways that empowered the students to bring their expertise into the classroom.

Mrs. Hanson allowed for multifaceted assessment that incorporates multiple forms, another example of a shift in power, which aligns with Ladson-Billings' conceptions of knowledge in CRP (Ladson-Billings, 1995b). During the PSA lesson at the end of the curriculum, we saw Mrs. Hanson demanding that her students make persuasive arguments meant to reach a broad audience that drew upon at least three pieces of scientific evidence from their data sets. While she accepted raps and cartoons alongside more traditional graphs and figures, she demanded a fluency with evidence and argumentation.

Furthermore, CRP takes time, which is also at odds with the current state of education in the United States, where teachers are pressured to cover many concepts and practices in a school year. Mrs. Hanson took more time than the curriculum called for to teach in a culturally relevant way. The "community survey" at the end of Unit 1, which was designed in the original curriculum as a homework activity, was *a* 7-day lesson on experimental design. At the same time that Mrs. Hanson taught explicitly about experimental design, she allowed her students to explore those aspects of the food system that seemed more important to them in their everyday lives, whether it be favorite candy bars or television commercials. She added in assignments to help students make connections and to critically analyze their knowledge and practices and science knowledge and practices. In an era when high-stakes testing dominates the discourse, CRP, which takes times, is marginalized.

While others have studied how boundary objects bridge (Cobb et al., 2003; Buxton et al., 2005) and push communities (C. P. Lee, 2007), the most important aspect we found in this study was how Mrs. Hanson used boundary objects in ways that transformed communities. Students in Mrs. Hanson's class were supported in taking on new roles that were integral to being successful in the unit. They were asked to be critical consumers of science and their everyday lives, a role not typically played in the science classroom. This role supported them in developing a critical consciousness toward their own and their communities' food and activity practices. The students were able to use their food and activity knowledge and experiences to push their understanding of how science was applied to their lives. Through the activities and discussions, the students uncovered different perspectives relevant to food and nutrition and engaged in serious deliberation with regard to their food choices. For example, after the students graphed their own food and activity data using bar graphs and examined and compared their data, they set goals for improving their food and activity practices. They attempted to change their eating and/or activity practices to lead healthier lives. The boundary objects (i.e., bar graphs, research questions) helped students pay attention to their worlds as they currently existed and empowered students to challenge their worlds. As Young (2010) states, "The role of a culturally relevant pedagogue is to invite students to question, challenge, and critique structural inequalities that exist in society, not to replace on hegemonic ideology with another" (pp. 254–255). Rodriguez (1998) defined empowerment as "the voice the individuals have to enact their rights and responsibilities" (p. 591). We believe that CRP should empower students, and that this case study of Mrs. Hanson demonstrates how students developed critical consciousness while learning science in ways that empowered them to make educated choices depending on their lives.

CONCLUSION

We argue for framing CRP in a way that pays particular attention to helping students develop critical consciousness. Mrs. Hanson used transformative boundary objects to connect and transform two sometimes disparate communities—home and school science—by consistently incorporating her students' cultural resources and expand and situate lessons in everyday life. Some of this may have been due to the nature of the curriculum; the curriculum called for the students to collect data on their eating and activity practices to learn about dynamic equilibrium. While this probably made it easier for Mrs. Hanson to draw on and incorporate her students' lives in the curriculum, we argue that Mrs. Hanson's teaching practices played an even larger role. Mrs. Hanson explicitly used boundary objects to incorporate cultural resources and situate lessons in everyday life through how she enacted the curriculum. She facilitated the creation of boundary objects that served to provide opportunities for students to draw on their various discourses in ways not often experienced in school science. In her teaching practices, she drew attention to how and why her students' everyday experiences were important in learning science. The students were able to use their own lives as legitimate sources of data collection, analysis, and discussion. This transformed the classroom from a traditional school science learning environment into a space that supported continuity between home and school, a critical examination of science practices and everyday lives, and empowered students to make educated decisions about their life practices.

We believe there is a greater need for research that examines *how science learning can empower students to enact change in their lives and communities.* Using transformative boundary objects helps students try on the norms and practices of science and legitimizes students everyday discourses and practices in ways that transform their learning are important aspects of becoming critically conscious. But science teaching and learning often falls short of helping students develop critical consciousness. Curriculum and teaching should provide students with opportunities to directly apply their learning to their lives in ways that transform both their science learning experiences and how they live their lives.

REFERENCES

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. Studies in Science Education, 27, 1–52.

Baker, E. A., Schootman, M., Barnidge, E., & Kelly, C. (2006). The role of race and poverty in access to foods that enable individuals to adhere to dietary guidelines. Preventing Chronic Disease, 3(3): A76.

Brickhouse, N. (1994). Bringing in the outsiders: Reshaping the sciences of the future. Journal of Curriculum Studies, 26(4), 401–416.

Buxton, C. A. (2010). Social problem solving through science: An approach to critical, place-based, science teaching and learning. Equity & Excellence in Education, 43(1), 120–135.

Buxton, C., Carlone, H. B., & Carlone, D. (2005). Boundary spanners as bridges of student and school Discourses in an urban science and mathematics high school. School Science and Mathematics, 105(6), 302–312.

Calabrese Barton, A., & Tan, E. (2009). Funds of knowledge, discourses and hybrid spaces. Journal of Research in Science Teaching, 46(1), 50–73.

Carlone, H. B., Haun-Frank, J., & Webb, A. (2011). Assessing equity beyond knowledge- and skills-based outcomes: A comparative ethnography of two fourth-grade reform-based science classrooms. Journal of Research in Science Teaching, 48(5), 459–485.

Cobb, P., McClain, K., Lamberg, D. T., & Dean, C. (2003). Situating teachers' instructional practices in the institutional setting of the school and district. Educational Researcher, 32(6), 13–24.

Fradd, S., & Lee, O. (1999). Teachers' roles in promoting science inquiry with students from diverse language backgrounds. Educational Researcher, 28(6), 14–20 and 42.

Gay, G. (2000). Culturally responsive teaching: Theory, research, and practice. New York: Teachers College Press.

Giles-Corti, B., & Donovan, R. J. (2002). The relative influence of individual, social and physical environment determinants of physical activity. Social Science & Medicine, 54(12),1793–1812.

Glaser, B. G., & Strauss, A. (1967). The discovery of grounded theory: Strategies for qualitative research. Chicago: Aldine Transaction.
Gutiérrez, K. D. (2008). Developing a sociocritical literacy in the third space. Reading Research Quarterly, 43(2), 148 – 164.
Gutiérrez, K., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertories of practice. Educational Researcher, 32(5), 19 – 25.
Institute of Medicine. (2007). Progress in preventing obesity: Health in the balance. Washington, DC: National Academies Press.
Johnston, L. D., Delva, J., & O'Malley, P. M. (2007). Soft drink availability, contracts, and revenues in American secondary schools. American Journal of Preventative Medicine, 33(4 Suppl.), S209 – S225.
Koch, P. A., Contento, I. R., & Calabrese Barton, A. (2010). Choice, control & change: Using science to make food and activity decisions: Linking food and the environment curriculum series. South Burlington, VT: National Gardening Association.
Ladson-Billings, G. (1994). The dream-keepers: Successful teachers of African American children. San Francisco: Jossey-Bass.
Ladson-Billings, G. (1995a). But that's just good teaching! The case for culturally relevant pedagogy. Theory Into Practice, 34(3), 159 – 165.
Ladson-Billings, G. (1995b). Toward a theory of culturally relevant pedagogy. American Educational Research Journal, 32(3), 465 – 491.
Ladson-Billings, G. (2006). It's not the culture of poverty, it's the poverty of culture: The problem with teacher education. Anthropology and Education Quarterly, 37(2), 104 – 109.
Lee, C. P. (2007). Boundary negotiating artifacts: Unbinding the routine of boundary objects and embracing the chaos in collaborative work. Computer Supported Cooperative Work, 16, 307 – 339.
Lee, O. (1999). Science knowledge, world views, and information sources and cultural contexts: Making sense after a natural disaster. American Educational Research Journal, 36(2), 187 – 219.
Lee, O. (2005). Science education with English language learners: Synthesis and research agenda. Review of Educational Research, 75(4), 491 – 530.
Lee, O., Luykx, A., Buxton, C., & Shaver, A. (2007). The challenge of altering elementary school teachers' beliefs and practices regarding linguistic and cultural diversity in science instruction. Journal of Research in Science Teaching, 44(9), 1269 – 1291.
Matthews, L. A. (2010). A case study examination of culturally relevant pedagogical practices for English-language learners in a pre-kindergarten classroom setting. Unpublished doctoral dissertation, Georgia State University.
Moje, E. B., Ciechanowski, K. M., Kramer, K., Ellis, L., Carrillo, R., & Collazo, T. (2004). Working toward third space in content area literacy: An examination of everyday funds of knowledge and Discourse. Reading Research Quarterly, 39(1), 38 – 70.
Moje, E. B., Collazo, T., Carrillo, R., & Marx, R. W. (2001). "Maestro, what is 'quality'?": Language, literacy and discourse in project-based science. Journal of Research in Science Teaching, 38(4), 469 – 498.
Moll, L. C., Amanti, C., Neff, D., & Gonzalez, N. (1992). Funds of knowledge for teaching: Using a qualitative approach to connect homes and classrooms. Theory Into Practice, 31(2), 132–141.
Morrison, K. A., Robbins, H. H., & Rose, D. G. (2008). Operationalizing culturally relevant pedagogy: A synthesis of classroom-based research. Equity & Excellence in Education, 41(4), 433 – 452.
National Research Council. (2011). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington DC: National Academies Press.
Ogden C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). Prevalence of obesity and trends in body mass index among U.S. children and adolescents, 1999 – 2010. Journal of the American Medical Association, 307(5), 483 – 90.
Ogden C. L., Fryar, C. D., Carroll, M. D., & Flegal, K. M. (2004). Mean body weight, height, and body mass index, United States 1960 – 2002. Advance Data, 347, 1 – 17.
Patton, M. Q. (1990). Qualitative evaluation and research methods (2nd ed.). Newbury Park, CA: Sage.
Phelan, P., Davidson, A. L., & Cao, H. T. (1991). Students' multiple words: Negotiating the boundaries of family, peer, and school cultures. Anthropology & Education Quarterly, 22(3), 224–250.
Powell, L. M., Szczypka, G., & Chaloupka, F. J. (2007). Adolescent exposure to food advertising on television. American Journal of Preventive Medicine, 33(4 Suppl.), S251 – S256.
Rodriguez, A. J. (1998). Strategies for counterresistance: Toward sociotransformative constructivism and learning to teach science for diversity and understanding. Journal of Research in Science Teaching, 35(6), 589 – 622.
Rogoff, B. (2007). The cultural nature of human development. New York: Oxford University Press.
Rosebery, A. S., Ogonowski, M., DiSchino, M., & Warren, B. (2010). "The coat traps all your body heat": Heterogeneity as fundamental to learning. Journal of the Learning Sciences, 19(3), 322 – 357.

Schlosser, E. (2001). Fast food nation: The dark side of the all-American meal. Boston: Houghton.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translations" and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–1939. Social Studies of Science, 19(3), 387–420.

Trompette, P., & Vinck, D. (2009). Revisiting the notion of boundary object. Revue d'Anthropologie des Connaissances, 3(1), 3–25.

Young, E. (2010). Challenges to conceptualizing and actualizing culturally relevant pedagogy: How viable is the theory in classroom practice? Journal of Teacher Education, 61(3), 248–260.

Upadhyay, B. (2010). Middle school teachers' perception of social justice: A study of two female teachers. Equity & Excellence in Education, 43(1), 56–71.

Upadhyay, B. (2006). Using students' lived experiences in an urban science classroom: An elementary school teacher's thinking. Science Education, 90, 94–110.

Varelas, M., Becker, J., Luster, B., & Wenzel, S. (2002). When genres meet: Inquiry into a sixth-grade urban science class. Journal of Research in Science Teaching, 39(7), 579–605.

Wenger, E. (1998). Communities of practice: Learning, meaning and identity. Cambridge, England: Cambridge University Press.