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Connecting Classroom Science with Everyday Life: Teachers' Attempts and Students' Insights

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Abstract This multiple case study examines how teachers request students' use of their content knowledge and conceptual understandings from out-of-school experiences while reasoning about science concepts and the ways in which students perceive and respond to these requests. Three middle school teachers and a total of 57 middle school students participated in this study. The data collection involved classroom observations and multiple interviews with each of the teachers individually and with small groups of students. The findings indicate that the students appreciate the usefulness of making relevant connections between their in-school and out-of-school learning, but seldom do so during science lessons. We also found that teachers' attempts to facilitate these types of connections during classroom discourse events involved the use of analogies, examples, or questions. Finally, the findings also indicate that students often recognize teachers' requests but seldom relate to these requests in the way the teacher intends.

Keywords Classroom discourse · Funds of knowledge · Science education

Introduction

Current reform efforts in K-12 science education emphasize the importance of instructional methods that engage students in the types of argumentative discourse that are characteristic of the social process of knowledge construction and require students to support their claims with appropriate evidence and reasoning (Sampson & Clark, 2008). This emphasis stems from the perspective that the ability to support and evaluate

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claims about natural phenomena using appropriate evidence and reasoning are essential practices in the field of science and should therefore be considered essential practices in K-12 science education as well (Duschl, Schweingruber & Shouse, 2007). Some researchers have asserted that to be successful, this argumentation process needs to draw from and use students' everyday knowledge and experiences (Lee, 2003). This assertion is based on the understanding that all students come to school with previously constructed knowledge as a result of their experiences at home and in their community and that learning is best facilitated when this knowledge is capitalized on. However, previous studies have shown that students seldom make these types of connections on their own (Cobern & Aikenhead, 1998). Efforts to better understand how science teachers might better work to support students in capitalizing on their knowledge and experiences from outside the classroom have primarily focused on the implementation of various curricular designs. These include the use of inquiry-based science activities (Cuevas, Lee, Hart & Deaktor, 2005), the integration of culturally relevant texts and other resources (Alvermann, Moon & Hagwood, 1999), and a focus on discipline-based language acquisition (Lee, 2003). However, very little research has focused on how students' knowledge and experiences from outside the classroom are capitalized on during classroom discourse events that focus on scientific reasoning. Eliciting students' use of their knowledge in these contexts is particularly challenging because it requires teachers to be flexible and resourceful in ways that cannot be embedded in curriculum materials or scripted into instructional routines (Carpenter, Lynn-Blanton, Cobb, Loef-Frank, Kaput & McClain, 2004). Instead, teachers are required to navigate the discourse they elicit based on in-the-moment pedagogical decisions. With the increased emphasis currently being placed on engaging students in argumentation and evidence-based reasoning, the ability to support students in making these valuable connections during classroom discourse events has become increasingly important.

This study addresses how students' content knowledge and conceptual understandings from out-of-school experiences are capitalized on during classroom discourse events that involve reasoning about scientific phenomena. This examination includes identifying the ways in which teachers request students' use of their knowledge and understandings from outside of school experiences in reasoning during science lessons and the ways in which students perceive and respond to these requests. Four questions are addressed: (1) In what ways do teachers request students' use of their knowledge and understanding from out of school experiences while reasoning about science concepts? (2) What sources of knowledge and experiences do students use in understanding scientific concepts? (3) What insights do students have about teachers' requests for them to use their knowledge and understandings from outside of school experiences while reasoning about science concepts? (4) What insights do students have about their own use of knowledge and understandings from outside of school experiences while reasoning about science concepts?

Theoretical Framework

This study operates from a sociocultural perspective that views learning and development as cultural processes. One of the influential ideas to result from

this perspective is that of instructional congruence. Lee and Fradd (1998) describe instructional congruence as the mediation of the nature of academic disciplines with students' linguistic and cultural experiences to make such content accessible, meaningful, and relevant. This notion emphasizes the need to develop congruence not only between students' cultural expectations and norms of classroom interaction but also between academic disciplines and the knowledge and understandings students bring from their out-of-school environments (Lee, 2002). Pedagogies addressing diversity in this way have various designations including culturally appropriate (Au & Jordan, 1981, p. 139), culturally relevant (Ladson-Billings, 1995), culturally responsive (Cazden & Leggett, 1981), and culturally congruent (Mohatt & Erickson, 1981). Conceptually, these all share the same emphasis on pedagogical orientations that empower students by linking curricular content to students' issues, concerns, and life experiences rather than taking a remedial, deficit-model view. The research in this area asserts that instructional congruence can serve as a conceptual and practical guideline for curricular design, teacher professional development, classroom practices, and student assessment (Luykx & Lee, 2007). Studies in this area also provide evidence that pedagogical approaches grounded in students' cultural backgrounds and everyday knowledge and experiences can make a positive difference in learning (Warren, Ballenger, Ogonowski, Rosebery & Hudicourt-Barnes, 2001).

Instructional congruence provides a useful conceptual framework for this study because it stresses the importance of acknowledging that students have knowledge and understandings gained from their out-of-school experiences that are relevant to science topics and can therefore be used as a resource for learning science. It also underscores the role of instruction (or instructional interventions) as teachers explore the relationship between academic disciplines and students' knowledge, devising ways to link the two (Lambert & Ariza, 2008).

Literature Review

González, Moll and Amanti (2005) used the term "funds of knowledge" to refer to the historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being. In their work, Gonzalez and her colleagues stress the importance of teachers understanding the home and community cultures of their students. They argued for teachers to spend more time visiting the homes of their students and interacting with their families and communities as a means of gaining insights that can be used to design more responsive learning experiences. From this perspective, the knowledge and understandings that result from students' out-of-school experiences are viewed as valuable resources for learning science.

The Chèche Konnen Project provides an example of some of the work that has been done to examine the complex, interactive, and complementary relationships between scientific practices and the everyday sense-making of children (Ballenger, 1997; Rosebery, Warren & Conant, 1992; Warren et al., 2001). This long line of programmatic research has conducted case studies of low-income students from African American, Haitian, and Latino backgrounds in bilingual and regular classrooms since

the late 1980s. The goal of this project is the promotion of collaborative scientific inquiry among students of diverse backgrounds as they learn to use language, to think, and to act as members of a science learning community. In one of the studies conducted during this project, researchers reported that they were able to accomplish this goal by identifying connections between Haitian students' skills in story-telling and argumentation and science inquiry, and then using those connections to support their learning of both the content and the practices of science (Rosebery et al., 1992). This line of research highlights the continuity between the forms of reasoning and argumentation characteristic of students of diverse backgrounds and those that are characteristic of scientific communities. It also highlights the importance of drawing upon students' knowledge and understandings from outside of school when engaged in scientific inquiry, reasoning, and argumentation.

In this study, the term "funds of knowledge" is used to describe the content knowledge and conceptual understandings students gain from their experiences in out-of-school contexts. While this includes students' cultural and linguistic practices, this study focuses primarily on the content knowledge and conceptual understandings related to science that result from these out-of-school experiences. In particular, we focus on how teachers use what familiarity they have with students' out-of-school lives to help facilitate connections with the knowledge and understandings gained from these contexts while engaging in argumentation and evidence-based reasoning. We recognize that this approach deviates somewhat from many works addressing students' funds of knowledge in that it fails to address how students' linguistic and cultural practices are capitalized on in formal science learning contexts. However, we view the content knowledge and conceptual understandings of scientific phenomena gained as a result of out-of-school experiences as an important aspect of students' funds of knowledge. Our interest in this aspect of the funds of knowledge construct stems from a desire to look beyond the practices of any one cultural demographic and instead focus on how students in classrooms with a diverse range of student cultures bring their knowledge to bear while reasoning about scientific phenomena. The work of Minstrell and van Zee (2003) provide an example of how teachers might facilitate connections between students' current content knowledge and conceptual understandings and new science concepts being discussed during science lessons. In their study examining Minstrell's classroom discourse practices, they documented Minstrell's use of students' understanding of mechanical springs to facilitate learning of passive forces. They found that having students discuss what they knew about mechanical springs helped establish a conceptual "anchor" (Camp & Clement, 1994) that helped them better understand the passive upward force exerted by a table on a book sitting on top of it. While the students' prior knowledge of mechanical springs may or may not have come from experiences outside of school, the approach used demonstrates how teachers might facilitate deeper understandings of scientific concepts by establishing conceptual anchors that can help students make sense of new concepts.

In this study, our interest is in understanding the strategies the teachers use to request students' connections with their funds of knowledge and how the students perceive and respond to the use of these strategies. We also wanted to gain insight into the sources of knowledge of students' reference during science discourse events. This interest stems from an appreciation for the science content knowledge and conceptual understandings that can result from students' experiences with scientific phenomena in out-of-school

contexts and a desire to better understand how this knowledge can best be leveraged during classroom discourse events.

Methods

This qualitative study uses a multiple case study methodology to gain insights into the ways teachers request students' use of their knowledge and understandings from out-of-school experiences while reasoning about science concepts and the ways in which students perceive and respond to these requests. Multiple case study methodologies are designed to help researchers develop complex and highly detailed understandings of an issue through detailed, in-depth data collection involving multiple sources of information (Creswell, 2007). This was a useful approach for this study because of the desire to explore how the issues examined occur in science classrooms. The data collected for this study include classroom observations, teacher and student interviews, curriculum documents, and student work.

Participants

Three middle school science teachers from two different schools in one school district in a small city in the Northwestern United States were recruited to participate. One of the schools (school A) has about 20% Hispanic students, while the other (school B) has about 6% Hispanic students. The second major minority student group in school A was American Indian (13%), while the major minority students in school B was Asian (10%). Black students were less than 2% in each school. In school A, 43% of the students participate in free and reduced lunch programs, and in school B, 36% participate in these programs. These schools were selected because most of the middle school-aged students in the community attend one of the two schools. All three participating teachers were Caucasians of European decent. One of the teachers was a male, and the other two were female. They were between the ages of 35 and 55, and each hold a Master of Science degree in the field of Science Education. Each of the teachers is also a long-term resident of the community in which the schools are located. Students in the classes observed were recruited for participation in this research study. In total, 57 students agreed to participate. Students who were members of the classes observed but chose not to participate in the research study were not intentionally videotaped or audio-recorded at any point during the study.

Data

The data collected include audio and video recordings of classroom observations, interviews with teachers, and interviews with students. For each of the three teacher participants, two lesson sequences that were identified by the teacher and the researchers as having a focus on engaging students in reasoning about scientific phenomena were chosen for inclusion in this study. These lesson sequences lasted between one and four days and were observed and audio and video recorded. For each lesson observed, one audio-video camera was set up to follow just the teacher throughout the lesson and separate audio-video cameras were used to capture the small group

interactions of participating students during select parts of the lessons. For the purposes of data collection, the teachers grouped participating students together during small group activities.

One of the three cases examined included Ms. A, a female eighth grade Earth Science teacher from school A and 20 of her students as study participants. The lesson sequences observed for this case included a Discovering Plate Boundaries lesson sequence that lasted three instructional days and a Modeling Seismic Activity lesson sequence that lasted two instructional days. The second case included Mr. B, a male seventh grade Physical Science teacher from school A and 13 of his students as study participants. The lesson sequences observed for this case included a Fractional Distillation lesson sequence that lasted four days and a Potential Energy lesson that lasted one day. And finally, the third case included Ms. C, a female eighth grade Earth Science teacher from school B and 24 of her students as study participants. The lesson sequences chosen for this case included a Continental Drift lesson sequence that lasted two days and an Axial Seamount lesson sequence that lasted three days. In the case of each lesson sequence included in the study, students were provided with opportunities to examine evidence related to scientific phenomena and reason about the possible conclusions that could be drawn from the evidence.

In choosing lessons for inclusion in the study, teachers were asked to identify lessons in which they planned to engage students in reasoning about scientific phenomena but were provided limited detail in regard to what about the reasoning was being investigated. Similarly, the student participants were only informed that the purpose of the study was to investigate teacher and student reasoning during science lessons. This approach was taken in an effort to minimize the impact of the study on the instruction that was provided and on the responses provided during student interviews.

The teacher participants were each interviewed four times. Before each lesson sequence, the teachers were interviewed to understand what the lessons were designed to accomplish and to gain insight into the reasoning they expected their students to engage in during the lessons. Teachers were also interviewed after each lesson sequence observed to better understand what occurred during the lessons and to gain insights into the teachers' thinking and intentions during the lessons. Each of these interviews was audio recorded, lasted up to 45 min, and was semi-structured in which the teacher was asked predetermined questions and then sub-questions were generated in a conversational manner to elicit more detailed or elaborate responses. Examples of the questions asked during the interviews with teachers can be found in Appendix A.

The student participants were interviewed in small groups three times during the study. Before the first of these interviews, their teacher randomly organized the student participants into groups of three or four. These groups remained the same throughout each of the rounds of interviews. Two of these rounds of interviews were based on the lessons observed, and the third round of interviews was conducted to gain further insights into students' use of their funds of knowledge during science lessons and their insights into their teachers' requests for them to use their funds of knowledge. Interviews in each of the three rounds were video and audio recorded and lasted up to 20 min.

The two interviews that were based on the lessons observed were conducted using a stimulated recall approach that involved recreating key aspects of the lessons, including small group activities and teacher-led discussions about the science concepts being

investigated. These stimulated recall interviews occurred within a week or two after the original lessons. At the discretion of the teacher, the students were taken out of their regular classroom into a conference room, empty classroom, or quiet hallway, and certain aspects of their lessons were reenacted with the researcher acting in a role similar to that of a teacher. The aspects of the lesson used for reenactments were chosen based on their potential to elicit student reasoning about the science concepts being investigated. For each interview conducted, this included a small group activity and a teacher-led, post-activity discussion about the science concepts being investigated. During these interviews, students were asked questions that were the same or similar to those asked by the teacher during the actual lessons. They were also asked additional questions designed to elicit responses that provided insight into their thinking during the lessons. Some of these questions were predetermined, and then, sub-questions were generated conversationally to elicit more detailed or elaborate responses. This approach was particularly useful for this study because the student thinking that occurred during the lessons was not always expressed verbally and was thus not captured in the original lesson recordings. The usefulness of the stimulated recall approach is that it provided students with the opportunity to explain what they were thinking during the lesson. Examples of the types of questions that were asked can be found in Appendix B.

The third round of student interviews was conducted to elicit students' insights into their own reasoning during the science lessons. In specific, students were asked about their tendencies to use, or not use, their out-of-school experiences to help make sense of science lessons. Also discussed were perceptions of their teachers' requests for them to use this knowledge during science lessons. Examples of the questions asked during these interviews can be found in Appendix C.

Member checks, in which participants were provided with the opportunity to review, assess, and offer corrections or further insight into how the information they provided was interpreted (Lincoln & Guba, 1985), were conducted with both teachers and students to ensure that the participants' meanings had been correctly interpreted. This was accomplished by asking for clarifications, rephrasing responses, and at times, asking for further insights. In addition, the teacher participants were provided with the opportunity to review the findings from this study and offer clarifications or further insights. Using this strategy ensured that the participants' contributions to the study were accurately represented.

Data Analysis

All video and audio data collected for this study were transcribed for analysis. The data analysis involved identifying instances in which students explicitly referenced content knowledge or conceptual understandings that were likely to have been gained from out-of-school experiences. The analysis also included identifying instances in which the teachers explicitly requested students to reference these types of knowledge. Previous research indicates that students draw upon a diversity of resources to learn science, many of which are not traditionally viewed as scientific (Moje, Tehani, Carillo & Marx, 2001). Adapting and expanding Moje, Ciechanowski, Kramer, Ellis, Carrillo and Collazo's (2004) framework characterizing student funds of knowledge in science, Calabrese Barton and Tan (2009) identified potential sources of these student funds as including experiences with their family, community, peers, and popular culture. The

analysis performed during this study used this framework to help identify instances in which students referenced their funds of knowledge and instances in which teachers requested students' use of knowledge from these sources. Examples of the types of knowledge considered for each source can be found in Table 1.

Findings

Teachers' Requests

Each of the teacher participants made multiple requests for students to reference their knowledge and understandings from out-of-school contexts during the lessons included in this study. For example, during the Modeling Seismic Activity lesson, Ms. A was engaging her students in a discussion about the movement of different earthquake waves. The reasoning that occurred during this discussion involved understanding the contracting and expanding that occur along a horizontal path in primary, or P-waves. During this discussion, Ms. A described how the movement of a P-wave is similar to that of a Slinky when it contracts and expands. In doing so, Ms. A was requesting that her students make connections between what they know about Slinkys and the science content being discussed. In this study, requests such as these came in the form of analogies, examples, and questions. Over the course of five instructional days, Ms. A made these kinds of requests eleven times, Mr. B five times, and Ms. C seven times (Table 2).

Analogies

The teachers' use of analogies while discussing science content was one of the most distinct ways in which they requested students' use of their funds of knowledge. In particular, Ms. A used analogies quite frequently. In fact, almost all of her attempts to request students' use of their funds of knowledge came in the form of analogies. During the lessons observed, she compared the science content to Oreo cookies, escalators, lava lamps, moving sidewalks, eggshells, conveyor belts, Slinkys, and snakes.

> So has anybody ever been on an escalator or a moving sidewalk? When you step on it, what happens? Ya, you start moving up or down. So the escalator is

Table 1 Funds of knowledge sources

Knowledge sources	Examples
Family	Food-related family practices; parents' and relatives' work; gardening; automotive repair and maintenance; budgeting; house maintenance; religion.
Community	Community gatherings like religious activities and celebrations; experiences in local restaurants and shops; sports and performance events.
Peer	Interactions with friends; peer talk; collaborative efforts toward a common goal (working together); engaging in common interests (playing together).
Popular culture	Music; magazines; television; movies; news media; the Internet.

Table 2 Teachers' requests for students to reference their funds of knowledge

Teacher	Analogies	Examples	Questions	Total requests
Ms. A	10	0	1	11
Mr. B	2	3	0	5
Ms. C	3	2	2	7

> moving, why are you moving? Ya, because you are standing on top of it. So the same idea applies to the asthenosphere. Because it is moving just like an escalator or moving sidewalk, the lithosphere is getting pushed or pulled.

Ms. C also used analogies during the lessons observed. One instance occurred during the Continental Drift lesson when she compared the rate of tectonic plate movement to the rate of fingernail growth, "So tectonic plates move about as fast as your fingernails grow. And that is about 5 to 10 centimeters a year. So look here at my yardstick. See the top part? This is about how much they move per year." The other instance occurred during the Axial Seamount lesson when she compared scientists to detectives, "Scientists are kind of like detectives. So being like a detective you might look at some of the evidence and be a little skeptical about some of the evidence you see over the next couple of weeks."

Mr. B was a little more subtle in his use of analogies, but through his dialog he twice tried to compare the tasks they were doing to things that the students might relate to as being fun, perhaps hoping that this would make the lessons more fun as a result. In one instance he refers to the Fractional Distillation lesson as being a *puzzle*, "We have a big puzzle on our hands. It is what are the two molecules that I am going to give to you today in a mixture that we are going to separate today." In another he refers to it is as a *game*, "I want to know what you think you have. That is what the game was. The game was to see what you had in your mixture. I want to know what you have to say."

Examples

In addition to using analogies, two of the teachers also occasionally used a strategy that involved the use of examples that they thought the students might be familiar with. Mr. B used this strategy three times during the lessons observed, and Ms. C used this strategy twice. The use of these examples represents clear attempts to make the material more relevant and meaningful by connecting the concepts with what they thought the students might be familiar with or interested in. For instance, during the Fractional Distillation lesson, Mr. B was trying to impress upon his students the importance of using multiple pieces of evidence to support claims when he used the example of a criminal case to make his point; "I mean you would be kicking and screaming if you were dragged to jail based on just saying oh your fingerprints matched. They need more." Ms. C also tried to use examples that she thought her students could relate to. During the Axial Seamount lesson, she tried to use a local area in one of her examples in the hopes that it would increase the students' interest; "We live here in [this state].

We might go to [this town] and stay on the beach with friends. Across the ocean is Japan, but all we see is a big expanse of water."

Questions

A third strategy the teachers used to request their students' use of their funds of knowledge from out-of-school experiences involved the use of questions. For example, during the Modeling Seismic Activity lesson, Ms. A was describing tectonic plate movements when she asked her students, "So what would we give as an example of how this works?" Ms. C also used this strategy. During the introduction to the Axial Seamount lesson, she asked her students two series of questions that involved requests for their funds of knowledge use. The first instance occurred while she was reasoning with students about whether or not volcanoes could erupt under water. She asked her students, "Do you know of any examples that show something like that could have happened?" One of her students responded by saying that she had been to the Hawaiian Islands and knew they were volcanoes. Ms. C responded by requesting that the student reaffirm what she meant by asking, "So are we saying that we know the Hawaiian Islands are volcanoes because we have been there?" In this instance, she was requesting that the students come up with their own examples to use as evidence of their assertion that volcanic eruptions can occur under water. In the second instance, she was trying to get students to relate the speed of tectonic plate movements to something they are familiar with when she asked, "So write in your notes, tectonic plates move as fast as … What do they move as fast as? Can you think of anything?" This strategy of questioning differs from the other two strategies described in this study in that it requested students' use of their funds of knowledge by asking them to make connections based on their own ideas. In the case of analogies and examples, the teachers took it upon themselves to provide the connections that they thought were most relevant and useful to students.

Insights into the teachers' intentions in using these strategies were provided during the pre- and post-lesson interviews. During these interviews, each of the teachers made it clear that they understand that students possess these types of resources and can

Table 3 Teachers' statements about connecting with students' funds of knowledge

Mr. B	Some were still trying to figure out what it was, but a lot knew it was some type of alcohol. And those two liquids are things they have dealt with before in their lives. They have rubbing alcohol in their homes and water obviously. So they have experience with these chemicals in their lives. Which is again making that connection with their experiences in the classroom and things they have dealt with at home on a real life basis in one way or another.
	Ask them how many people have had family members with radiation treatment or X-rays. Everyone in the room has had some type of medical treatment that deals with radiation in their lifetime.
	Well it seemed like I tried to find ways to make it more relevant to them. A lot of these kids have seen TV shows with CSI and who done it kind of thing. Which is again making that connection with their experiences in the classroom and things they have dealt with at home on a real life basis in one way or another.
Ms. A	I think it is important for them to make connections with their full range of experiences.
Ms. C	I have to help them make those [connections].

benefit from opportunities to incorporate them into science lessons. Examples of these statements can be found in Table 3.

In addition, Ms. C seemed to appreciate that some of her lessons could either privilege or marginalize students depending on their background experiences. For example, during the post-lesson interview based on the Continental Drift lesson, she was discussing the reasoning she expected the students to engage in during the activity around which the lesson was designed. This activity required students to place fossils on different parts of a world map based on a description of the location where they were originally found. The students were then supposed to use this information along with the shape of the continents to create what they thought Pangaea might have looked like. While discussing this part of the lesson, she mentioned her surprise at the difficulty some students had with determining where the fossils should be placed and reflected on why they may have struggled.

> I think those judgment calls are a little biased in the background knowledge that the students have about the geography of the world. There are those who have heard of Pangaea and seen pictures of it, so it depends on their background knowledge. Even brief exposures to this could predispose them to be more successful, however you define success.

Statements such as these clearly demonstrate the teachers' appreciation for the important role that prior knowledge plays in helping students understand new science content. They also provide insight into the teachers' intentions in using the strategies observed in this study as a means of supporting students in making these types of connections.

Students' Use of Their Funds of Knowledge

The students in this study very seldom made explicit reference to knowledge and understandings gained from out-of-school experiences during the discourse events included in this study. There were instances in each case in which the students referenced knowledge or experiences from outside of school, but these instances did not occur with any great frequency. Ms. A's students, for instance, only exhibited the use of their funds of knowledge once during the discourse events included in this study, and that occurred during one of the lesson-based interviews. This instance involved the use of a crime scene as an example to explain the importance of gathering multiple pieces of evidence to strengthen a claim (Table 3). Even in this case, it is not clear if this example is indicative of the student's funds of knowledge use or if the student is just re-using one of the teachers' examples.

Ms. C's students also did not often explicitly reference knowledge and understandings gained from out-of-school experiences. The few instances in which her students' referenced these funds of knowledge primarily involved references to television shows, particularly those aired on the Discovery channel. For example, during an interview based on the Continental Drift lesson, the students and the researcher were debriefing an activity that involved using paper cutouts of the shapes of current continents to try to piece together how the continents might have fit together in the past. After engaging in this activity, the students were asked if it helped them understand anything better. Their

responses varied in terms of whether it helped or not, but in three different instances, students mentioned their previous experiences with television shows as being influential in their thinking (Table 4).

For the most part, Mr. B's students also demonstrated relatively infrequent use of their funds of knowledge during the lessons and lesson-based interviews. The lone exception to this trend occurred when Mr. B's students were asked to justify their claim as to the identity of one of the mystery liquids. Students had almost universally determined that one of the substances involved was alcohol. Of the 15 instances in which Mr. B's students exhibited the use of their funds, almost all of them came in relation to the question of why they thought the substance was alcohol. The lesson involved a density calculation and a flammability test as a means of identifying the substances. While there seemed to be ample opportunity to refer to the data from these tests, many students chose instead to reference knowledge gained from their out-of-school lives. Some examples of these statements are provided in Table 4.

Students' Insights into Their Own Funds of Knowledge Use

The student participants did not often make explicit reference to knowledge and understandings gained from out-of-school experiences during the reasoning events captured in this study. While it is very possible the students did not have funds of knowledge applicable to the content being discussed, it is also possible that they did have applicable funds but were either not making connections with this knowledge or were making connections but were not explicitly talking about them. To gain further insights into how students were actually thinking in these contexts, they were asked during the final round of interviews, "When you are doing your science lessons do you think about things from outside of school to help you make sense of new ideas?" In

Table 4 Examples of students' use of their funds of knowledge

Teacher	Student statements
Ms. A	Ya like a crime scene. Like evidence and then it is like I suspect these people and then with more evidence you can narrow it down into the final.
Ms. C	Ummm, no. I had already seen this on Discovery Channel sometime in elementary school.
	Well, I thought it was interesting because I saw lots of stuff we learned in school and Discovery when I was younger. But never really listened to any of the facts or anything when they didn't actually have it on TV. And so I find it interesting to see the actual proof behind it.
	Um, hum. And more understanding how it works because when I watched it on TV I was like, oh, that's so cool, but now I'm like, oh, I actually understand that now.
Mr. B	The doctor's office smells like that and I know they use alcohol.
	It smelled like nail polish remover.
	Lots of things. My parents. Geez is that bad?
	We have some in our cabinets where we keep all our medicine.
	When we first separated our liquids we kind of had an idea because it smelled like the doctor's office.
	In a video game you can take a bottle of alcohol and put a cloth in the opening, light it, and throw it like, like throw it at somebody.

each of the 12 student groups asked this question, one or more student responses indicated feelings of separation between their in-school and out-of-school lives. Some of these students also indicated that they do not really think about their out-of-school experiences during their lessons as a result. Table 5 provides examples of students' statements about this issue.

The statements made by students confirm what was observed during the reasoning events included in this study. They also provide some insight into students' thinking during their science lessons in general. As stated earlier, we acknowledged that it was possible the students were using content knowledge and conceptual understandings gained from experiences in out-of-school contexts during the reasoning events observed but were not being explicit in their use of these resources. The statements made by students during these interviews indicate that not only are they not being explicit about their use of knowledge and understandings from these sources, they are in fact not accessing these resources with any regularity during their science lessons. From the students' perspective, this is happening because of a lack of connection between the different contexts. In their own words, they "just don't connect them that much" because "it doesn't seem relevant". However, when the students were asked if it helps them understand science concepts better when they can relate them to things they learned from outside of class, some of the students indicated that they think it does. For example, one of Ms. A's students described how, "It makes it a little bit easier to comprehend I guess because you have more things to base it off of. Like more things you know for sure." In another instance, a group of Mr. B's students was talking about how we use science in real life everyday, but we do not really think about it during science class. In response to this, one of the students in the group commented that, "it would help if we did though because then we would understand it better. But we don't." Based on statements such as these, it seems as if some students appreciate the

Table 5 Examples of students' statements about the separation of their in-school and out-of-school lives

Example 1	Inside of school and outside of school is like two different lives.
Example 2	I don't really think about outside of school stuff when I am in school unless I am bored. Our school life and our outside life is separate. Unless it is brought up.
Example 3	When you are inside school, you don't really think about outside of school as much.
Example 4	Not many things I do outside of school really relate to what I do in lessons. There is no connection.
Example 5	I don't know. I separate school and life into two different categories. Like school is its own little bucket of knowledge and then there is the rest of life. I also separate school and life. I usually forget most of the things I use in school, especially over the summer time.
Example 6	I don't really get how it helps you understand things during class. Ya, me too. It doesn't seem relevant. I don't really put the things I learn in school to the things I learn in life. I am not just like oh this is kind of the same. I just don't connect them that much.
Example 7	Well it is like if you are at school you are talking about school, and if you are out in life, then you are talking about life. So when we were talking about lessons then that is what we are talking about.

usefulness of making relevant connections between their in-school and out-of-school lives, but they experience challenges in doing so during their lessons.

Students' Insights into Their Teachers' Requests

During this final round of interviews, students were also asked questions about their teachers' requests for them to use their relevant knowledge and understandings from out-of-school experiences during science lessons. This line of questioning involved first determining whether or not the students even recognized their teacher's requests. If they did recognize their teachers' requests, the students were also asked what they thought about these requests and if they helped them learn the concepts in the lessons better.

In each of the 12 groups engaged in this line of questioning, the students, as a group, were quick to appreciate that their teachers made these types of requests as a means of helping them make connections with their knowledge and experiences from outside of school. Mr. B's students, for example, picked up on his tendency to use examples as a means of helping them make connections. They talked about how "he tries to relate like everything to real life", and "like some stuff in physics he uses like dropping a ball or jumping out of an airplane as examples". Ms. A's students were also observant of her requests. They mentioned her use of analogies during lessons, particularly those involving food. Examples of student statements from each of the teachers' classes can be found in Table 6.

When asked what they thought about these kinds of requests, a few of the students in this study made comments about how, "It helps like 90% of the class." "It definitely puts a picture in your mind." and "I can visualize it better". However, most of the comments made in response to this question were about how they found it difficult to relate to what their teachers were talking about. For example, one of Mr. B's students talked about how the examples used were somewhat out of date and therefore difficult to relate to.

> Like 10 years ago he might have been the best teacher ever, but now kids don't know what he is talking about. We can't relate to his examples. He brings in like weird toys instead of like Lego's or something we can relate to.

Table 6 Examples of students' statements recognizing their teachers' requests

Ms. A's students	Ya, she compares things to stuff all the time.
	A lot of food references.
	Ya like she asks if we understand and if we don't she goes over it again. She always relates things to food. It is terrible.
	She talked about chocolate cake and the center of the earth. Everything is food.
Mr. B's students	He tries to relate like everything to real life
	Like some stuff in physics he uses like dropping a ball or jumping out of an airplane as examples.
	And roller coasters.
Ms. C's students	She makes references and brings in examples
	She uses like metaphors and analogies

Some of Ms. A's students also found that the concepts she was requesting they make connections with were difficult to relate to. For example, one student expressed this by saying, "I kind of think about things differently so when she tries to compare stuff it does not really make that much sense, not for me anyway." Another group of her students went on to talk about the difficulties involved in trying to relate to every student. They described how, "Everyone is a little different" and as a result, "everyone has different things that they have learned outside of school so I don't think she could." Some of Ms. C's students also seemed to appreciate how hard it is to connect with every student. In one instance, a student described why she felt it might not be worth the effort.

> I think she could try but it would be more trouble than it was worth because it would take so long to try to relate things to everybody at school's lives outside of school. It would be boring. People would be getting bored and I don't think it would work.

In another instance, one of her students indicates her appreciation for the difficulties involved in helping students make connections with their previous knowledge and then proceeds to offer some insights into an approach that she thinks might be useful.

> It would be easier if they like asked us about what we already know. Like science, I did not really know a lot of stuff back in elementary school. So she could have figured out first what we know and then explain it to us based on that.

Comments such as these indicate that the students appreciate the difficulties involved in helping them make relevant connections between their science lessons and their out-of-school experiences. From their previous comments in this interview, it is also evident that the students themselves also have difficulties making these connections on their own. Ideas about how the findings from this study can be used to provide insight into how teachers might better facilitate these connections are presented in the "Discussion" section.

Discussion

The teachers involved in this study were each long-term members of the community in which their schools were located and were confident they had some amount of insight into the home lives and community cultures of their students as a result. This study was designed to gain insight into how these teachers used these insights to support students in capitalizing on their funds of knowledge during classroom discourse events that focused on argumentation and evidence-based reasoning. We also sought insight into how the students perceived and responded to these efforts. What we found is that the teachers appreciated the importance of helping students make connections with their funds of knowledge in these contexts and used a variety of well-documented strategies in their attempts to facilitate them, including the use of analogies, examples, and questions. We also found that the students in this study rarely made explicit reference to their funds of knowledge in these contexts and seldom responded to their teachers'

attempts to help facilitate connections in the way the teachers intended. These findings are similar to those of Moje et al. (2004), who found that the urban youth they followed in and out of the school setting rarely volunteered everyday knowledge in science classrooms, even when their prior experiences were relevant to the current science topic. From the perspective of the students involved in this study, this occurred as a result of distinct feelings of separation between their in-school and out-of-school lives. In addition, when the teachers in this study attempted to support students in making these types of connections, the students indicated that they found the analogies and examples used by their teachers to be incongruent with their own experiences and understandings and therefore not helpful to their efforts to understand the concepts discussed. In the words of one student, "We can't relate to his examples".

These findings indicate that facilitating connections between students' funds of knowledge and the science content discussed during classroom discourse events requires more than just teacher-initiated requests. Each of the teachers in this study attempted to facilitate these types of connections during the discourse events included in this study, but most of the attempts were not as effective as they had intended. In addition, it is possible that despite the good intentions of the teachers, the strategies used could in some cases contribute to inequalities in instruction rather than diminish them. For instance, while teachers' use of analogies and examples are perhaps important means of helping students connect with the topics of a lesson, the analogies and examples observed in this study were based on the teachers' assumptions about the connections that might benefit students. Because of this, there was little assurance that the students would be able to relate to the analogies or examples provided. It is possible that approaches such as these can lead to subtle inequities by privileging the students who are more familiar with the references and are therefore more likely to grasp their implied correlation with the topic of discussion. This notion is supported by the findings from previous studies indicating that teachers tend to recognize and draw on knowledge that is only familiar to a select group of students, and that as a result, many other students are unintentionally disadvantaged by a fundamental lack of alignment between their own funds of knowledge and those of the teacher (Vélez-Ibáñez & Greenberg, 2005). The students in this study addressed this issue when they talked about how they recognized their teachers' requests for them to make relevant connections between their prior knowledge and the topics discussed, but found it difficult to relate to the analogies and examples used.

The question-asking strategy used by the teachers in this study differs from these approaches in that it encourages students to draw upon their own resources to make connections in ways that are meaningful to them. Asking students questions such as "Can you think of anything that this relates to?" and "So what would we give as an example of how this works?" invites students to consider a range of potential conceptual anchors, including those that have resulted from out-of-school experiences. Previous studies investigating the application of funds of knowledge in formal learning experiences have identified teacher modeling such as this as a potentially powerful influence on classrooms cultures (Hogg, 2011). Teachers' regular use of questions as a means of supporting students' use of their funds of knowledge may have the potential to help facilitate the development of classroom cultures in which students understand

that the use of these resources is not only acceptable during science lessons but also encouraged. However, the attempts observed in this study mostly failed to elicit students' use of their funds of knowledge in the way the teachers intended.

The findings from this study, particularly the insights provided by the students, provide evidence for the necessity of considering a variety of instructional practices in conjunction with each other to facilitate students' use of their funds of knowledge during classroom discourse events. As was the case in this study, teachers who model the use of funds of knowledge and who invite students to consider connections of their own may still fail to facilitate students' use of their funds in these contexts. In light of this, we posit that efforts to facilitate students' connections with their funds of knowledge during classroom discourse events should begin at the curricular level and then be supported by the discourse practices of the teacher. Evidence for this assertion is provided in the form of the one instance in this study in which the students did make somewhat prolific references to their funds of knowledge. This instance occurred during the interview debriefing of the Fractional Distillation lesson in Mr. B's class. Despite opportunities to cite evidence from flame and density tests, the students instead referred to their funds of knowledge as a means of supporting their assertion that one of the mystery substances was alcohol. We believe this was a result of the design of the lesson. This lesson differed from the others included in this study in that it required students to identify the substance based on their own analysis. While the teacher predetermined the substances and procedures used in the activity, the evidence and reasoning cited were their own. In the other lesson sequences included in the study, students were asked to examine evidence from studies previously conducted as a means of supporting their assertions. In these instances, the students were simply working to comprehend how existing scientific theories were formed. It is possible that by engaging students in the process of discovery rather than presenting discoveries to them, Mr. B was able to situate his requests for students to reference their funds of knowledge in a context in which they felt rightful owners of knowledge relevant to science. In doing so, he may have increased the effectiveness of the discourse strategies he used to elicit these connections while reasoning with his students about the scientific phenomena targeted by the lesson.

These findings support the work that has been conducted by other researchers in that they indicate curricular designs as an essential element in facilitating students' use of their funds of knowledge (Bouillion & Gomez, 2001). While teacher requests during the discourse events might model the usefulness of the approach and provide students with opportunities to make useful connections, these strategies by themselves may not be effective. In order to effectively elicit students' use of their funds, teachers may need to design lessons which are grounded in contexts that may be familiar to students, provide them with opportunities to engage in science practices in ways that might better position them as rightful owners of knowledge relevant to science, and work to elicit these understandings during classroom discourse events.

Conclusion

In terms of providing insight into how to provide more accessible science instruction, this study highlights several key considerations. The first is that students need support

in using their funds of knowledge to understand science concepts. The feelings of separation between in-school and out-of-school contexts expressed by the students in this study represent a clear barrier to effective instruction. Because students seldom make these connections on their own, it is necessary for teachers to employ strategies that support them. Secondly, while the strategies teachers use in requesting students' use of their funds of knowledge are designed to facilitate equitable instruction, some may actually contribute to inequalities. Because of this, careful consideration of the impact of different types of requests is warranted. This is especially true in classrooms with students from a diverse range of backgrounds. Lastly, we argue for the use of supports from multiple levels of class instruction used in conjunction with each other as a means of facilitating students' use of their funds of knowledge during classroom discourse events that involve reasoning about scientific phenomena. These include curricular designs that engage students in explaining phenomena or solving problems that are contextualized and have consequence to students, and teacher discourse practices that model and request funds of knowledge use.

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