MAKING CONNECTIONS BETWEEN FORMAL SCHOOL EARTH SCIENCE AND LIVED EXPERIENCES: AN INVESTIGATION OF URBAN FIFTH GRADERS

By

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For Chris, who picks me up, calms me down, and has made this whole process worth it

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MAKING CONNECTIONS BETWEEN FORMAL SCHOOL EARTH SCIENCE AND LIVED EXPERIENCES: AN INVESTIGATION OF URBAN FIFTH GRADERS

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Using constructivist grounded theory and the framework of place-based education, this dissertation, presented in manuscript format, investigated how urban fifth graders describe, identify, and make connections between formal/school earth science concepts and their own everyday lives. Six urban fifth grade participants were observed during their earth science unit and interviewed twice over the course of that unit. Data collected involved individual interviews supported by auto-driven photo elicitation.

By focusing specifically on students' connection making processes and decisions, this study sought to explain how students identify and describe connections they make between earth science in school and in their lives outside of school. Its findings, presented as a manuscript submitted to a peer-reviewed science education research journal, produced a theory explaining the role of direction observation and indirect connections through use of analogies in students' connection making. This theory argues that urban fifth graders make the strongest connections to formal earth science concepts when they can directly observe them in their immediate surroundings, and that when these students cannot directly observe these earth science concepts in their immediate surroundings, they bridge the gap between their classroom learning and their

lived experiences through analogies of appearance, structure, or response/behavior. Furthermore, this study's findings highlighted the critical role, and potential source of confusion, in the non-rock or man-altered materials commonly found in urban environments, including concrete, brick, and asphalt.

The implications of this study were then used to inform the design of a 5E earth science lesson, which was taught in a fourth-grade class. The lesson, student work samples, and teacher feedback on the lesson's utility were submitted to a peer-reviewed practitioner journal in order to bridge theory and practice. Ultimately, the lessons learned as a result of teaching the 5E earth science lesson provided concrete solutions to the problem this study examined.

CHAPTER 1
INTRODUCTION

Statement of the Problem

Constructivism is an epistemology which states that individuals come to knowledge in a personal and subjective way. That is to say, learners create knowledge for themselves rather than acquire it, and this process of knowledge creation is socially mediated. This contrasts with positivism, which as an epistemology holds that knowledge is permanent, universal, and acquired by learners through a process of transmission from experts. Embracing constructivist learning theory in order to make sense of science concepts and processes as well as the social context of learning, teachers must provide students with experiences and opportunities in which the students can interact with others while making sense of scientific concepts and practices. Better student science learning therefore occurs when learners make connections between their previous experiences or everyday lives and concepts and processes they encounter in formal science classes.

Students come to school with rudimentary understandings and representations of the phenomena that science explains. “These representations are constructed, communicated, and validated within everyday culture…. [and] evolve as individuals live within a culture” (Driver, Asoko, Leach, Mortimer, & Scott, 1994, p. 11). These naive representations of such phenomena are often times very different from the way they are taught and explained in the science classroom. Embracing the learning theory of constructivism, that meaningful learning occurs when the learner is able to make connections to past experiences, such disconnects can make science learning difficult (Lee & Fradd, 1998; Parsons, 2008; Warren, Ballenger, Ogonowski, Rosebery, &

Hudicourt-Barnes, 2001). By choosing to include artifacts, examples, and resources familiar to students, the teacher can remedy these disconnects (Lee, Deaktor, Enders, & Lambert, 2008). However, before a teacher can decide which connections to use in teaching a certain science topic for a certain group of students, she must first seek to understand what the possible connections are between the scientific phenomena and children's lived experiences (Lee, et al., 2008).

Moore (2008) attributes the disconnect between students' lived experiences and the lived experiences classroom teachers use to teach formal earth science concepts to situations in which teachers come from different backgrounds (racially, culturally, and socioeconomically) than her students. The teacher's understanding of the possible connections to the lives of her students may be difficult to identify based on her own lived experience. The current situation nationwide shows that while our nation's schools grow more diverse, the teaching force is much less diverse, leading to a situation in many classrooms where the teachers are not able to connect the science content to their students' everyday lives in ways to encourage meaningful learning. The most recent Condition of Education report (Aud, et al., 2010), summarized and reported on the 2007-08 school year statistics, which demonstrate this trend. The report showed that 17 percent of public schools were high-poverty schools, defined as having 75 percent or more students eligible for free or reduced price lunch (FRPL) and 20 percent of elementary students attended high-poverty schools. Among those high-poverty elementary schools, "46 percent of students…were Hispanic, 34 percent were Black, 14 percent were White" (Aud, et al., 2010, p. 84). Urban cities had the highest percentage

(40 percent) of high-poverty elementary schools, but the racial patterns among high-poverty schools “held for cities, suburban areas, and towns” (Aud, et al., 2010, p. 84).

Conversely, the teaching population of our nation’s public elementary schools for those same years was 84 percent female and were racially/ethnically distributed as 82 percent White, 7 percent Black, 8 percent Hispanic, and 3 percent other (pp. 88-9). No data on teacher’s socioeconomic (SES) backgrounds were given, but 99 percent had earned a bachelor’s degree or higher. In order to compare the average SES background of students, it is important to note that in 2007-08 the USDA’s Income Eligibility Guidelines stated that to qualify for FRLP (Free and Reduced Lunch Program), a family of four had to make less than $20,650 per year (United States Department of Agriculture, 2007, pp. 86-87). Conversely, the average teacher nationally in 2007-08 made $52,308 (mean)/$47,248 (median) (National Education Association, 2008, p. 19). Thus, a difference between students and teachers in high-poverty schools in terms of race, culture, and SES status can be inferred.

Taken as a whole, this situation presents a problem. Classroom teachers have a responsibility to provide urban students of color and of poverty the best possible science education they can to foster broader participation in the scientific enterprise. By providing students learning experiences that connect to their lived experiences, these teachers create conditions which allow their students the best chances to close persisting gaps on achievement tests which act as gatekeepers to future opportunities. However, the United States have a large number of classrooms in high-poverty, urban, elementary schools with white, middle-class teachers - teachers who may not have the life experiences necessary to connect the science content they teach to the lives of their high-poverty, urban students. This disconnect between everyday ways of knowing and scientific ways of knowing has been cited as a potential cause of the science achievement gaps noted for many marginalized groups and making the science "connect" has been one common suggestion to confront this problem (Bouillon & Gomez, 2001; Calabrese Barton, 2001; Calabrese Barton & Tobin, 2001; Fusco, 2001; Settlage & Southerland, 2007; Tobin, 2005; Warren, et al., 2001).

Many science educators call for school science to connect to the lives of the students. For example, Lee and associates (2008), after investigating the science learning of culturally and linguistically diverse elementary students from six schools in a large urban area, called for teachers "to use cultural artifacts, examples, analogies, and community resources that are familiar to students to make science relevant and intelligible to them" (p. 728). Also, Bouillon and Gomez (2001) found, when researching fifth grade urban students, that by learning about ecosystems using a nearby river the students demonstrated a deeper understanding of ecosystem science and an understanding of the nature of science as it applied to a local context.

Purpose of the Study

Finding ways to make formal earth science connect more easily to urban students' lives is of considerable importance. While multiple research studies have been conducted on the benefits of connecting science with urban students' lives in general (e.g.,Calabrese Barton, 2001; Calabrese Barton & Osborne, 2001; Calabrese Barton & Tobin, 2001; Tobin, 2005; Tobin, Roth, & Zimmerman, 2001), researchers have conducted minimal work on connecting geoscience with students' lives. Additionally problematic for the purposes of this study, this previous work connects primarily with the lived experiences of indigenous populations (e.g.,Bevier, Evenchick, Thompson, &

Wyss, 1997; Murray, 1997; Riggs, 2005; Semken, 2005; Semken & Morgan, 1997), and not the lived experiences of urban students of color and of poverty.

Given this hole in the research literature, and the importance of making geoscience education more personal and more relevant to urban students of color and of poverty, this study explored how urban fifth graders describe, identify, and make connections between formal earth science concepts as they are taught in school and where they appear in their everyday lives. Given the previously discussed disconnect between the lived experiences of teachers and students, this study explored how urban students themselves act as “local experts” and “cultural translators” of their own experiences (Aikenhead, Calabrese Barton, & Chinn, 2006, pp. 408, 413). By understanding how students develop cognitive links between formal earth science concepts and where they see them in their everyday lives, this research will enable classroom teachers - who may be disconnected from their students’ experiences on grounds of race, ethnicity, or socioeconomic status - to create better science learning experiences for their urban students of color and of poverty.

Research Question

RQ1: How do urban fifth graders describe, identify, and make connections between formal school earth science and their lived experience?

Significance of the Study

This study produced a number of insights regarding earth science instruction in urban elementary schools, and has laid the groundwork for bringing place-based education into those schools. These insights have the potential to increase urban elementary students’ meaningful understandings of earth science content through the use of local examples. By investigating how students in these schools identify, describe, and make connections between formal earth science content and instances of this content in their everyday lives, this research has the potential to aid classroom teachers in providing more appropriate earth science learning experiences while capitalizing on their students' lived experiences. This study's use of auto-driven photo elicitation methods to elicit students' ideas and examples additionally lays new ground in the science education research literature, showing the possibilities the methods offer in producing rich data including students' voices and personal collections of artifacts such as pictures while allowing them to participate actively in the research. Finally, this study generated a theory of how students in urban environments make personal and meaningful earth science connections, opening the door for science education researchers in other contexts to examine the theory's utility for science teacher classroom practices and further question students' connections-making and meanings-making.

Dissertation Overview

This chapter includes a statement of the problem this dissertation addresses, and its significance to the field of science education. Chapter 2 provides a review of several categories of relevant literature, including historical and modern perspectives on science education, research in urban and geoscience education, the intersection of these two fields, and a survey of the framework for place-based education. Chapter 3 details the dissertation study's design, including a discussion of its epistemological foundations, portraits of the study's participants, a survey of auto-driven photo elicitation and its role in data collection, and treatment of the role Charmazian grounded theory methods played in data analysis and theory generation. Chapter 4 presents the findings of this study in research manuscript format, which has been submitted to the *Journal of*

Research in Science Teaching and is currently under review. While conducting research is an integral part of the dissertation process, bridging the gap between educational theory and classroom practice is an equally important goal of teacher education. Therefore, Chapter 5 presents a practitioner-oriented article based on an earth science lesson which was developed, based on the research findings of this study, and implemented in an upper elementary Texas classroom. This article has been submitted to *Science and Children* and is currently under review. Finally, Chapter 6 presents an overview of the dissertation project and provides further discussion and conclusions for the study as a whole.

CHAPTER 2
REVIEW OF THE LITERATURE

To examine some of the unique features related to urban elementary geoscience education, this literature review provides a discussion of the research in each of the subcategories relevant to this study. It presents each subcategory of research separately and as they overlap within the specific intersection of place-based urban elementary geoscience education. First, it presents a general overview of the history of science education and the current state of equity issues in science education. Second, it summarizes the state of urban education and urban science education in the United States, including a focus on research connecting science to urban students' lives. Third, it reviews the literature on geoscience education, discussing the focus on student conceptions and misconceptions, as well as research on urban geoscience education. Fourth, it presents a detailed discussion of the literature most related to my research in urban elementary geoscience education. Finally, it presents place-based education as my theoretical framework, discussing why that framework was selected and what the framework includes. This chapter also discusses how this research will contribute to the bodies of scholarship on place-based education, urban science education, and elementary geoscience education.

Historical and Modern Perspectives in Science Education

For at least the last 100 years, science education has swung back and forth between two ideals of what science in school should be - either as a study of the scientific disciplines and science as a structured body of knowledge to be learned, or as a study of the natural, physical world as it relates to social relevance and student interest. In the early 20th century, an influx of immigrants and increased urbanization caused education to focus on schooling for social control and social efficiency (DeBoer, 1991). Science education mirrored these foci with the decision to reorganize secondary education, seen in the establishment of the Commission for the Reorganization of Secondary Education (CRSE) and its science committee (National Education Association, 1918, 1920). The CRSE specifically called for science education to change and focus on social relevance (DeBoer, 1991), which would set a foundation for the coming Progressive Era.

In 1917, the United States entered its Progressive Era in education (1917-1957), which held as core tenets support for child-centered education, the critical need to include real-world applications to content learning, the importance of knowledge to a strong society, and the overall goal of making school both meaningful and enjoyable to students (DeBoer, 1991). The Progressive Era saw strengthened focus in science education of these same core tenets, especially as seen in major reports of the period (Noll & Henry, 1947; Powers & Whipple, 1932). From the 1920s to the 1950s, science education shifted from a focus on disciplinary study to a focus on social relevance and student interest (DeBoer, 1991), but the change did not last.

By the 1950s, the foci of the Progressive Era were dying in both public policy and classroom practice and focus returned toward mastery of the traditional disciplines. Numerous fronts drove this shift, including fears over worker shortages brought on by WWII, perceived threats of the Cold War and competition with Russia, and claims by traditionalist educators and scientists that progressive science education ruined traditional American intellectual values (DeBoer, 1991). However, this shift increased dramatically after 1957, when the USSR launched *Sputnik*. Critics of progressive education saw this event as indicative of the United States' failing science education system, and in response they began the Curriculum Reform Movement (CRM). The CRM represented a decade of both focus on disciplines and process of science and of federal involvement in science education. The CRM made some excellent contributions still seen in science education today, including a focus on increased rigor and increased instruction for students on how to think and act like scientists. However, the CRM tended to ignore student interest and pedagogies needed to relate science knowledge to the student's world (DeBoer, 1991).

As the 1960s ended, public concern about the Cold War and competing with Russia lessened and concern turned toward providing equitable education for all students, specifically students from historically marginalized groups. A variety of conditions, including the Civil Rights Movement, the Vietnam War, persistent poverty in urban areas, and wide-spread prejudices around ethnicity and gender stimulated education laws and court ruling to be enacted to remedy vast inequities in American public schools and to insure educational equity regardless of race, gender, language, or disability ("*Brown*," 1954; "Education for All Handicapped Children Act," 1975; "*Lau v. Nichols*," 1974; "Title I of the Elementary and Secondary Education Act," 1965; "Title IX of the Higher Education Act," 1972). This movement brought with it increased attention to social relevance and student interest in education. However, in science education it also brought about the idea of scientific literacy, which would remain a dominant focus for the next forty years.

The National Science Teachers' Association (NSTA) identified "scientific literacy" as an important major goal in science education in 1971 (National Science Teachers

Association, 1971). However, they never officially defined the term and, as such, supporters used the label to support a wide variety of science education goals. Paul DeHart Hurd, a early and chief supporter of scientific literacy in science education, discussed scientific literacy as an understanding of science and its applications to society and the everyday-world (DeBoer, 1991). Conversely, in a 1963 survey of scientists and science educators, most respondents defined scientific literacy as a focus on greater content knowledge in a broad range of science fields (DeBoer, 1991). Thus, both sides of the discipline-based vs. socially relevant science education debate adopted the term "scientific literacy" quickly for their own purposes.

Since then, scientific literacy has continued to be a part of science education policy. In the 1990s, educational policymakers included scientific literacy in a collection of science education reform documents that were published, including *Science for All Americans* and the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1989, 1993), and the *National Science Education Standards* (National Research Council, 1996). These documents called for science education that provided student-centered, activity-based, quality science instruction for all students at all levels towards the goal of scientific literacy. They conceived of scientific literacy as aiming to solve four commonly recognized problems in science education: low levels of science content knowledge in members of the national population; inadequate science teaching in schools; lack of citizen preparation to use scientific knowledge in everyday decision-making; and to increase the percentage of women and minorities in science fields (Eisenhart, Finkel, & Marion, 1996). The documents presented "scientific literacy" for all Americans as "the educational solution to these problems" and urged the United

States to make this the overarching goal of science education reform (Eisenhart, et al., 1996).

Science educators were receptive to each of major reform documents of the 1990s, and these documents presently remain excellent calls for rigorous academic standards in science and improved teaching in schools. However, since then, science educators have presented numerous critiques of the documents. One particular complaint is that the documents promote a “universalist” view of science, which views the natural world as following a consistent set of rules and a science that should be practiced the same way by all people at all times (Cobern, 1993; Lee & Buxton, 2010; Lee & Luykx, 2006). This universalist view of science appears in *Science for All Americans,* in that “science assumes that the universe is, as its name implies, a vast single system in which the basic rules are everywhere the same. Knowledge gained from studying one part of the universe is applicable to other parts” (AAAS, 1989, pp. 3-4). The problem with a universalist view of science is that it presents science as devoid of culture, as merely existing in the universe, not as a set of ideas developed by humans over the course of our collective existence. Additionally, it does not recognize how race, culture, ethnicity, language, gender, or other social factors have influenced (and continue to influence) science knowledge and practice (Lee & Buxton, 2010).

Also, while science educators originally welcomed the reform efforts of the NRC and AAAS for having noble, egalitarian goals that were seen as “crucial to bringing about equity” (Calabrese Barton, 2003b, p. 26), some have recently criticized them for continuing to view the needs of many minorities (e.g., girls, high-poverty, urban students, non-English language learners [ELLs], and racial and cultural minority students) though the deficit model (Lee & Fradd, 1998; Rodriguez, 1997; Roth & Calabrese Barton, 2004; Seiler, 2001).

The deficit model brings with it three assumptions that are problematic towards an empowering science for these target populations (Calabrese Barton, 2003b). First, students in these populations are lacking in Western science knowledge and need extra educational opportunities to "catch up" to their peers. Second, those students will learn to accept and prioritize the ways of Western science or it is their fault, not due to faulty pedagogy or content decisions. Finally, schools are meritocracies and science achievement scores reflect a student's effort and ability, not his/her "degree of enculturation" into Western science (Calabrese Barton, 2003b, p. 26). Sadly, there are few places where the negative effect of the deficit view is as obvious and pronounced as in urban areas.

Research in Urban Education

Urban Education in the United States

The Census Bureau defines urbanized areas (UAs) as "one or more places and the adjacent densely settled surrounding territory that together have a minimum of 50,000 persons" (United States Census Bureau, 1995). The 2000 Census estimated that 75% of the US population lived in these UAs, while "central cities", the largest actually incorporated city in a UA, held 29% of the population. It is these central cities (ex. New York, Houston, Los Angeles, Miami) that urban education research tends to focus on and these central cities are typically share two common factors: large populations of ethnic minorities and high incidence of poverty.

Calabrese Barton (Calabrese Barton, 2001) identified four key factors that she felt characterized urban centers. First, urban center populations are usually more than 50%

ethnic minorities, with minority populations in New York being 57%, Houston 60%, and Detroit 79%. Second, large populations of immigrant families live in urban centers, with the majority of foreign-born US residents living in urban centers in California, New York, Florida, and Texas. Third, urban centers are largely affected by poverty, with 21% of urban children living in poverty and 50% being near the federal poverty level at some time in their lives. Finally, poverty affects urban minorities of color disproportionally when compared to white children of poverty. Even though white children make up the majority of children in poverty in terms of absolute numbers, children from ethnic minority families, specifically Hispanic and African American families, are statistically more represented in statistics on poverty rates. The poverty rate in 1998 was 8% for Whites, 25% for Hispanics, and 26% for African Americans, with chronic (or generational) poverty commonly seen for urban African American children "at both the family and neighborhood level" (p. 903).

Similarly, urban schools are characterized as having the following conditions: high levels of poverty, high populations of ethnic minorities, below grade level English proficiency, high student mobility, low student achievement, attendance issues, lack of resources, strict behavior control, strong focus on high stakes testing, issues recruiting and retaining well trained teachers, lack of support for innovative teaching practices, inattention to home-school connections, and prioritized ways of knowing in the curriculum. This multitude of conditions in urban schools, leads to students not receiving equitable educations in these schools (Calabrese Barton, 1998, 2001, 2002, 2007; Endreny, 2010; Geier, et al., 2008; Kahle, Meece, & Scantlebury, 2000; Norman, Ault, Bentz, & Meskimen, 2001; Oakes, Muir, & Joseph, 2000; Spillane, Diamond, Walker, Halverson, & Jita, 2001). As such, it becomes easier to understand why a variety of educational achievement gaps have been identified between urban and non-urban students, between high-poverty and non-high-poverty urban students, and between ethnic, racial, and socioeconomic groups (Calabrese Barton, 2007; Norman, et al., 2001).

Urban Science Education

The problems mentioned previously - high concentrations of generational, familial poverty, underfunded and underresourced schools, and curricula focused on lower-order thinking and high-stakes testing - plague all aspects of the urban student's education. Given the focus America has placed on providing a proper science education since the launch of Sputnik, ensuring all students - including urban students of color and poverty - receive a quality science education is essential to create a more diverse scientific workforce, but also to equip all Americans with scientific literacy. It is for this reason, coupled with social justice concerns, that a group of researchers study urban science education, examining the crossroads of urban conditions and science education in the schools (Basu & Calabrese Barton, 2007; Bouillon & Gomez, 2001; Lewis & Baker, 2010; Moje, Collazo, Carillo, & Marx, 2001; Seiler, 2001; Seiler, Tobin, & Sokolic, 2001; Spillane, et al., 2001; Tobin, Elmesky, & Seiler, 2005; Tobin, et al., 2001; Tobin, Seiler, & Walls, 1999; Warren, et al., 2001). This group conducts research that is not simply situated in urban schools, but also deals with the constructs (people, structures, and cultures) that affect life in that particular urban area (Calabrese Barton, 2002). Therefore, while they use different framework and conclude different things, their overall research agenda is similar and reflects the idea that urban science education research should focus on "the intersections among students, their families and their teachers, science, schooling, and the historical, physical, environmental, social, economic, and political aspects of urban life" (Calabrese Barton, 2007, p. 321).

Moje and associates (Moje, et al., 2001) researched the role of culture and Discourse in urban middle school science with a large population of Hispanic and non-mainstream students. They documented the competing Discourses that were used during one project-based, seventh grade unit and showed that most often in these classrooms, the discourse of science is privileged over everyday forms of social discourse. They propose the construct of 'congruent third space' as an idea to help eliminate this prejudice against the discourse used most comfortably by urban learners by not only bridging connections between community and school, but working toward authentic integration of Discourses from both.

In another study of urban, predominately Hispanic students, Bouillon and Gomez (2001) also looked at the disconnect between school and community, but using a local, field-based project to specifically teach ecology content. Using the real-world, local problem of a polluted river near the school, they researched the use of "mutual benefit partnerships" (MBPs) between urban fifth graders and their community. MBPs are noted as having four specific features: a) use of a "real-world" community-based problem, b) use of community-school or business-school partnerships, c) use of problem-based learning, and d) use of student-developed questions and projects. Results of their MBP showed increased student understanding of ecology concepts and skills, increased student efficacy in science, and increased interest in further participating in science. This research shows how the movement of science out of the classroom and into the community, paired with a student-generated project and support from community members, led to both cognitive and affective gains in urban students.

In contrast to studies supporting misconception and cultural congruence work, or work that assumes a disconnect between school and everyday science knowledge, Warren and associates (2001) propose that researchers stop analyzing the disconnects and focus on researching how the two can be seen as fundamentally continuous. Using case studies from one Haitian American and one Latino student, they show how poor and minority children used their everyday experiences to provide both context and perspective when learning about science processes. This research shows that student’s everyday ways of knowing science can be successfully used to enhance science learning when facilitated by willing and prepared instructors.

Also noting the importance of willing and motivated science teachers, Spillane and associates (2001) investigated how teachers and leaders at 13 high poverty Chicago elementary schools identified and used what is around them (material, human, and social capital) to create more equitable science learning for their students. Using multiple forms of data collection, including observations and video of teaching and meetings, and structured and semi-structured interviews with school and science leaders, they showed how teachers activated human, social, financial, and material resources. To do this, school leaders built relationships through connections with local universities and colleges, consultants from science institutions, and the school district itself, which helped the school identify and utilize more resources for teaching science. This shows the importance in considering low-resourced, urban schools as having (or needing to establish) networks of resources, and not simply focusing on the lack of resources within the school.

According to Tobin, Elmesky, and Seiler (2005), urban science needs to connect to areas germane to the lives and interests of students if it is to be academically useful. Additionally, this allows for the students to interact in networks that include adults outside their gender, social class, and ethnic groups, which provides the students the social capital necessary for social mobility, or the potential to break-out of generational poverty. Good urban science education can also work to counter a number of the problems typically seen in urban environments including the effects of tracking, teaching to the test, and student resistance to strictly academic learning (Seiler, et al., 2001; Seiler, Tobin, & Sokolic, 2003; Tobin, et al., 1999). Ultimately, by connecting science instruction to students' lives, and teaching in a fashion that is culturally conscious, urban science educators can work toward engendering science fluency (Tobin, 2005), leading toward the goal of scientific literacy.

In response to continued low academic achievement, underfunded and under resourced schools, and disconnected science schooling practices in urban schools, researchers have undertaken a variety of ways to help address this disparity. The major ways are through use of appropriation frameworks, inclusion of legitimate participation, and teaching science through congruence (Calabrese Barton, 2007). However, they all share the common goal of making science education connect with the lives of urban students and of better using the resources available in urban school environments.

Connecting Science to Urban Students' Lives

There are many science educators doing research on ways to make science more accessible for all students, specifically those who have been marginalized in the past , like women (Brickhouse, Lowery, & Schultz, 2000; Tan & Calabrese Barton, 2008; Topping, 2006), ethnic minorities (Basu & Calabrese Barton, 2007; B. A. Brown, 2006; Calabrese Barton & Yang, 2000; Griffiard & Wandersee, 1999; Kahle, et al., 2000; Yong, 1992), persons from poverty (Calabrese Barton, 1998; Calabrese Barton & Osborne, 2001; Fusco, 2001; Upadhyay, 2006), and urban students (Atwater, Wiggins, & Gardner, 1995; Buxton, 2006; Calabrese Barton, Tan, & Rivet, 2008; Griffiard & Wandersee, 1999; Hewson, Kahle, Scantlebury, & Davies, 2001). Most agree that "Science for All" should be a goal of science education and conduct research to improve the noted discrepancies between majority and minority groups. Some believe that this should be done using "appropriation frameworks", or tools that help students assimilate or appropriate science content and culture into their own knowledge and culture. These include use of genres (Varelas, Becker, Luster, & Wenzel, 2002), everyday sense-making (Warren, et al., 2001), and cultural tool-kits (Calabrese Barton, 1998; Elmesky, 2003; Seiler, 2001).

Others call for "legitimate participation", meaning the students are "afforded formal learning opportunities to participate in authentic science or science-like experiences" (Calabrese Barton, 2007, p. 333), and result in students being valid members or contributors to a science community. Research and programs supporting legitimate participation go by many titles, including "project-based science" (PBS) (Schneider, Krajcik, Marx, & Soloway, 2002), "emergent learning experiences" (Calabrese Barton, 2001, 2003a; Calabrese Barton & Darkside, 2000; Fusco, 2001; Fusco & Calabrese Barton, 2001; Rahm, 2002), and "multiscience" (Hammond, 2001).

Finally, the third major camp of science educators doing research on supporting cultural and linguistic minorities in learning science are those seeking “congruence” or building bridges between students’ cultural knowledge and experience and the culture and content of school science (Lee & Luykx, 2006). Congruence plays prominently in research on “congruent third-space” (Moje, et al., 2001), “instructional congruence” (Lee & Fradd, 1998), “culturally congruent instruction” (Parsons, 2008), “composite culture” (Hogan & Corey, 2001), and “bridging affordances of real world problems” (Bouillon & Gomez, 2001).

These three ideas differ both in the methods used to make sense of student learning in urban environments and in their implications for science education. Studies using appropriation frameworks show the variety of resources students use to learn science, especially those they bring to the classroom from outside science. These frameworks also show how conflict in science classrooms arise when high-stakes tests only value one way of knowing and discussing science, and provide ideas for how those conflicts could be minimized. Studies using legitimate participation opportunities recognize the importance of science as a verb that is done by students, not as a discipline of instruction to be acquired. They raise debate over what “authentic” and “meaningful” science includes and excludes, and they challenge the current goals of science education and current methods of assessment. Studies seeking congruence in science education frequently use a bridge metaphor, as in the methods provide ease in transitioning back and forth between science in school and science as it exists in everyday life, and in recognizing that the two do (and should) connect. They also contribute the idea that there are multiple different cultures surrounding how and what students learn, and that some of those cultures can conflict if not negotiated carefully. They demand that good science leads to empowerment of students and is at all times viewed by the learner as relevant to his or her life outside of science class.

As different as these research agendas may seem, they have a common element. Most have the idea of science that is related to the students' lives as a key component to promoting equitable learning in science for all students. Some explicitly call for "relevant" science. For example, Parson's (2008) research on "culturally congruent instruction" calls for "teaching content via relevant examples" (p. 667). Also, Bouillon's and Gomez's (2001) work on "bridging affordances" has as a main component that problems chosen were "relevant and of interest to the curriculum and students' lives" (p. 891). Similarly, Tobin, Elmesky, and Seiler (2005) believe students should be "provided with opportunities to learn science in forms that are relevant and significant to everyday life" (p. 310). Others use related ideas like "student-centered learning" where science is "a collection of topics connected to [student's] everyday lived experiences" (Seiler, 2001, p. 1007), and "congruent third-space" which notes the "importance of constructing spaces where students can bring their knowledge and everyday Discourses to bear on science knowledge" (Moje, et al., 2001, p. 492).

The idea of connecting science to urban students' lives seems to permeate this literature. For example, Fusco's (2001) reasoned her work with students and urban gardens "was relevant because it (a) was created from participants' concerns, interests, and experiences in and outside science, (b) was an ongoing process of researching and then enacting ideas, and (c) was situated within the broader community" (p. 872). Similarly, Lee and associates' (2008) call for teachers to "use cultural artifacts, examples, analogies, and community resources that are familiar to students" for using these will "make science relevant and intelligible" (p. 728).

Summary

Conditions in urban schools are very much unlike conditions in suburban schools. It is these conditions which result in urban students receiving an education that is both fundamentally inequitable and academically insufficient. In urban science education, this inferior instruction has led to urban students performing poorly on state, national, and international standardized assessments. Additionally, as urban areas tend to act as clusters for ethnic and linguistic minorities, poor science education in urban schools is seen as contributing to the lack of ethnic and linguistic minorities pursuing science degrees and careers.

Amongst researchers seeking to improve conditions in urban science education, the major areas of urban science education research include (a) use of appropriation frameworks, (b) inclusion of legitimate participation, or (c) teaching science through cultural congruence. While they all share the common goal of making science education connect with the lives of urban students and using the resources available in urban school environments more readily, this study draws most strongly from the cultural congruence group, as my research sought to identify ways students connect geoscience in school to geoscience in their everyday lives.

Research in Geoscience Education

Survey of the Field

Geoscience is a field of natural science that studies the composition, structure, and various physical processes of the Earth (and other planets), and Earth's geologic past. It includes studies of: (a) Earth's layers; (b) Earth's landforms and water bodies, including earthquakes, volcanoes, tsunamis, tectonic plates, and mountains; (c) Earth's atmosphere, including weather; (d) human uses of Earth's naturally occurring resources, including groundwater, minerals, metals, and petroleum; and (e) the effects of using Earth's resources on various environments.

In conducting a review of the literature on K-20 geoscience education, there were three main themes: research on field work experiences, research on place-based (PB) and/or culturally relevant geoscience education with Native American and Canadian populations, and conceptions and misconceptions awareness in geoscience.

In research on field work experiences in geoscience, Gunckel (1994) led groups of fifth and sixth graders in a one-day geology field project to an active, geologic fossil bed, where students sampled outcrops and leaf fossils while experiencing scientific inquiry around a question of their choosing. Based on analysis of his observation data, Gunckel concludes that pursuing a line of research questioning developed by the student leads to the learner having the unique opportunity to experience the strengths and weaknesses of scientific inquiry in an actual science research setting. Likewise, Halocha (2005) analyzed post-fieldwork drawings/writings of 150 eleven-year-olds who had visited the coast during a unit of study on coastal processes, including erosion and deposition. While on a one-day field trip to an English coastline beach, students conducted a variety of activities including counting wave frequency and considering the role of the wind, and collection of water samples to observe particulate matter and sediment being eroded by the water. Students also participated in a construction exercise where, as a group, students had to build a structure to protect their group stick from the coming waves. As the tide came in, students were able to watch the effects of the waves on their structures to see how successful their models had been. The lead teacher noted it was this activity that engaged the students most while on the trip and Halocha found that students' information was most complete around the stick activity. The findings of both of these project highlight the importance of choosing appropriate and engaging activities that students can feel a personal connection with when conducting field work.

A fair amount of research has been done on using place-based (PB) and/or culturally relevant geoscience education with Native American populations and First Nations populations in Canada (Bevier, et al., 1997; Dubiel, 1997; Murray, 1997; Semken, 2005; Semken & Morgan, 1997; Vierling, Frykholm, & Glasson, 2006). Amongst these, a few specifically used PBE in research on geoscience education, such as Semken and associates' (Semken, 2005; Semken & Freeman, 2008; Semken & Morgan, 1997) work redesigning an introductory geology course to include Dine (Navajo) models of natural systems and exploration of the local Colorado Plateau. Dubiel (1997) also worked with the Navajo, but with Navajo Nation teachers in a week-long professional development to improve their geology knowledge as well as allowing them to collect their own geology kits with local rocks for use in their classroom. In Canada, Murray (1997) researched the use of "ethnogeology" with members of the Cree Nation in northern Manitoba, and Bevier (1997) researched teaching adult First Nations students from British Columbia how local geology related to aboriginal legends.

While the specific findings of each of these studies varied, they described three common features, which are all noted as important qualities in research involving teaching geoscience to indigenous/native populations (Riggs, 2005). First, these studies gave major support to place-based curricula, specifically use of experiential, outdoor science taking place within the traditional areas of the indigenous groups, or areas where the students were very familiar. Second, these studies gave respect to the indigenous/native ways of knowing, including scientific knowledge, by including this information along with more Western science ideas whenever appropriate. Third, these studies each recognized the importance of involving members of the indigenous/native communities in all areas of curriculum design and delivery. Indigenous community elders and educators were consulted regarding both indigenous science knowledge content, and location and methods ideas for more traditional (Western) science instruction (Riggs, 2005). Taken together, these three features highlight important considerations when beginning research on science teaching and learning in native/indigenous populations in order to ensure high levels of respect and success.

More than both field-world and native/indigenous population research in geoscience education, research on misconceptions/alternative conceptions in geoscience education constituted the bulk of the research in K-20 geoscience education. This research includes specific studies of learner's ideas on geologic time (Kusnick, 2002; Trend, 1998, 2001), fossil fuels (Rule, 2005), weathering and erosion (Dove, 1997; Russell, Longden, McGuigan, & Bell, 1993, as cited in Dove, 1998), earth's structure (Lillo, 1994; Sharp, Mackintosh, & Seedhouse, 1995), and rocks (Dahl, Anderson, & Libarkin, 2005; Dove, 1996; Ford, 2003, 2005; Hawley, 2002; Kusnick, 2002).

As mentioned earlier, this research is guided by a constructivist epistemology. Within a constructivist framework of learning, students enter school with their own ideas, models, and theories of the world (Sneider & Ohadi, 1998), including conceptions that explain some of the scientific phenomena taught in school (J. P. Smith, III, diSessa, & Roschelle, 1993). When student's conceptions are different from currently accepted scientific explanations, they are often labeled as misconceptions. I use the term misconception as defined by Smith and associates (1993) as "a student conception that produces a systematic pattern of errors" (p. 119). Once formed, misconceptions are difficult to eliminate and may persist into adulthood. Incomplete experiences, faulty explanations, and misunderstood meanings (Martin, Sexton, & Gerlovich, 2001) are some of the common causes of misconceptions being developed.

The process of effective science teaching and learning can resolve these misconceptions and a great number of books and article have been published with suggestions on confronting and overcoming misconceptions in science. While most agree that the first step in addressing misconceptions with both children and adults is to cause the learner to feel dissatisfied with their current ideas, there are many strategies suggested to help cause this dissonance. Some of these strategies include, use of formative assessment probes (Keeley, Eberle, & Farris, 2005; Keeley, Eberle, & Tugel, 2007), use of discrepant event demonstrations or explorations (S. R. Smith & Abell, 2008), 2008), and use of the learning cycle (P. L. Brown & Abell, 2007; Hardy, Jonen, Möller, & Stern, 2006), while specifically targeting instruction to common address misconceptions (Maria, 1997; Stein & Goetz, 2008).

Kusnick (2002) argues that, even though science educators have exerted considerable effort in physics, biology, and chemistry to identify students' misconceptions, comparably work in the earth sciences has been limited. This has resulted in a relatively limited section of research on geoscience misconceptions and even less research on where common geoscience misconceptions come from and how they can be addressed in the classroom. Henriques (2002) states that "most teachers are far too busy to gather misconception data from their students or from the research" (p. 206), so science education researchers must take up the call to address this need.

Student Conceptions and Misconceptions

Some geoscience education research has sought to understand the root causes of common misconceptions in earth science (Dove, 1998; Ford, 2005). Dove (1998) presents a review of research in this area and discusses eleven possible sources of misconceptions in geoscience education:

1. The imprecise use of language and use of everyday language in science contexts
2. Changing definitions over time
3. The oversimplification of concepts and generalized statements
4. Overlapping concepts
5. Use of rote learning
6. Personification, or giving inanimate objects human/animal characteristics
7. Textbook stereotyping of landforms
8. Inadequate use of prerequisite knowledge of students
9. Inability of students to perceive change over time
10. Students inability to visualize cross-section or what is below earth's surface
11. Student's inability to recognize that features of similar appearance can have differing origins (p. 193-197)

Of these possible sources, recent misconception research suggests a few consistently, which the following section discusses below, focusing on specific area misconceptions, including geologic time, Earth's layers, soil, rocks, weathering and erosion, and the role of humans in geoscience processes.

Geologic time

The concept of geologic time is "particularly troublesome for children and their teachers" (Ford, 2003, p. 374) as it involves grasping concepts of millions and billions of years. Trend (1998, 2001) has studied ten- and eleven-year-old children's understanding of geologic time and the vast amounts of time necessary for rock formation. He found that they have trouble placing major geologic events in their place in time and typically think of time in two categories, "extremely" and "less" ancient. Perhaps this is due to a lack of observation data, as observable geologic events rarely occur in human life times. In a related study, Kusnick (2002) found that even after receiving instruction on geologic rates and the geologic time line, undergraduate preservice teachers still tended to "place humans in stories of rock formation" (p. 36). Therefore, it is perhaps understandable that many elementary students also have a anthropocentric idea of geologic time.

Earth's layers

Frequently, science curricula in the United States introduce students to the different layers of Earth during elementary and middle school. However, research shows a number of those students leave with large misconceptions about where these layers occur and what they do (Lillo, 1994; Sharp, et al., 1995). In a study of eleven-to-fifteen-year-olds in Spain, Lillo (1994) asked the students to draw and label a cross-section of the Earth. While most correctly drew the layers as a series of concentric circles, some showed inaccurate ideas like a magnet in the center of the Earth and volcanic magma coming out on the surface directly from a hot, melted core. Lillo noted that the majority of the students drew a two-dimensional model of Earth’s layers and questioned the influence of previous models used in instruction. Sharp and associates (1995) also studied nine- and ten-year-old children’s conceptions of Earth’s layers, finding that his respondents expressed confusion on whether Earth’s core was hotter or colder than the surface. Amongst those who incorrectly believed the core to be colder than the surface, reasoning for this difference varied, including the idea that the sun’s rays could not reach the core to heat it, the idea that cold water seeped into the ground to lower the center’s temperature, and the idea that Earth’s core was colder in winter than in summer. Sharp and associates concluded that students frequently used both personal experience and representations of the Earth from popular media in explanations of geoscience content involving Earth’s layers. Like the findings on geologic time misconceptions, these misconceptions regarding Earth’s layers are potentially related to the inability of children to directly observe the location of parts of the system (Dove, 1998).

Soil

To a geoscientist, soil is the upper most layer of Earth’s lithosphere and is a mixture of weathered rocks of different sizes, minerals, and a variety of organic (living and dead) matter. Soil is the nutrient rich layer in which things grow and typically extend only a few feet beneath the surface. However, to children, and many non-geoscientists, soil is a subject about which many misconceptions exist. Students’ soil misconceptions include issues of composition, depth, and age. In their study of British five-to-eleven-year-old children’s perceptions of soil, Russell and associates (1993) found that children think “real soil” should be homogenous and brown. Therefore, the students rejected all sand, small pebbles, and chalky soil as “soil”, accepting only the garden soil and dark compost matter as matching that term. Many of the students thought that soil had no air in it and the twigs, bark, and leaf parts were considered to be found in the soil, but not a part of the soil. The same was true of small stones, sand, and clay found in soil samples. Additionally, when asked if rock could become soil, some believed rock could break into smaller fragments, but others thought rocks were too hard to break into soil. Dove (1998) notes other common soil misconceptions including the idea that soil "formed when the Earth formed", is unchanging, and can "extend for several miles under Earth's surface" (p. 191).

Rocks

The largest number of studies reported on students' (elementary and undergraduate) conceptions of rocks including what a rock is, the origin of rocks, how to identify certain rocks, and how rocks are categorized. When attempting to define what a rock is, researchers have found that, even within science classes, students typically can either not define what a rock is (Hawley, 2002) or they define "rock" the way it is used in common everyday language (Ford, 2003). Several studies identify the use of everyday language in a scientific context in Earth science as a potential source of students' alternative conceptions (Dove, 1996; Russell, et al., 1993). These studies also noted this issue in usage of other terms, such as using "marble" to refer to any polished rock (Dove, 1996), or using "pebble" whenever referring to any small stone. In science, marble is the term used for the metamorphic rock that is created when limestone is changed due to heat and pressure. Likewise, pebble is the scientific term for any piece of broken rock measuring between 2 to 64 mm, placing it between gravel (which is smaller) and cobbles (which are larger).

In a study of thirty-four suburban fourth graders, Ford (2005) found that children used similar descriptors for both minerals and rocks. In describing minerals, children used categories like feel/texture (rough, sharp, smooth), color (white, clear, pink, green), luster (shiny, sparkly), and shape (cube, rectangle). In describing rocks, they also used the descriptors of feel/texture and color, but did not include luster and usually used a simile in describing shape. For example, one student described her rock as "shaped like a mountain" and another said his rock was "shape as a fish head" (p. 286).

One of the oldest studies of children's understanding of rocks was conducted by Piaget in 1929. As part of his larger study of children and natural phenomena, Piaget discussed the origin of stones with 5-11 year olds in Switzerland. He found that many of the younger children (under 8) reported stones as being created by humans or God, or as growing from planted seeds (Piaget, 2007). Wier, Cain, and Fredricks (2000, as cited in Ford, 2003) also found that their third graders thought rocks could be formed by humans. This misconception is hypothesized to originate from the classic elementary activities where students "make rocks" from evaporated sand/silt/clay mixtures or using everyday materials or food in models of the rock cycle. However, in Piaget's study, by age 9-10 most children could state that rocks formed naturally, with some explaining that earth changed into sand and sand particles hardened together into rock. The misconception of rocks forming on Earth's surface through some form of growth or bonding is still a misconception noted in students of all ages. Kusnick (2002) found that amongst undergraduates studied, 50% of students "described some form of 'clast accretion process' in rock formation, such as growing pebbles, globs of minerals that ‘melt together,’ etc.” (p. 34). This shows that misconceptions about how rocks form continue to persist into adulthood if not properly addressed in school.

Even after instruction, researchers noted children and adults continued to hold major misconceptions when asked to identify and/or classify rocks. Students had difficulty choosing appropriate features of the rocks to observe and note. Ford (2005) noted that, while some children identified features for their rock and mineral samples that were consistent with “geologically relevant properties”, others noted “features of the samples that were unique to each sample, rather than representative of the class/type of rock or mineral” (p. 288). Others similarly found that both children (Russell, et al., 1993) and adults (Dove, 1996), commonly consider color to be an important feature in identifying specific rock types, such as sandstone and limestone. This resulted in issues as Dove (1998) explains “sandstone was perceived as orange in colour and consequently brown and white varieties went unrecognized. Similarly, a grey limestone was not identified because students thought this rock type should have been yellow or white” (p. 185). One noted suggestion to help ameliorate this misconception would be use of a wide variety of specimens of limestone and sandstone for students to examine, to challenge their stereotypical images of these rock types (Dove, 1998).

Another common misconception was that students assumed that where they found a clast specimen (rock sample) was where it originated (Ford, 2003). Other issues of origin arose in students assuming that landforms and rocks that were similar in appearance had similar origins. Dove (1996) considered this misconception problematic because students mistakenly classified slate as a sedimentary, not a metamorphic, rock because it exhibited layering. They also mistakenly considered volcanic pumice a sandstone, because it contained holes (Dove, 1998).

Other misconceptions involving rock classification and identification included the belief that rocks, stones, and pebbles were separate entities from their parent rock (Russell, et al., 1993), and the beliefs that conglomerate was cement and coal was a fuel, not a rock (Dove, 1996). Regarding the bulk of misconceptions on this topic, Hawley (2002) commented that the students demonstrated they had “no clear conceptual framework with which to investigate, classify, and associate rocks and rock types” (p. 364).

Weathering and erosion

Many misconceptions exist in the field of sedimentology around the processes of weathering and erosion. Geologically speaking, weathering is the breaking down of rock and erosion is the movement of that broken rock, which ends with deposition. People commonly confuse these processes because they generally occur concurrently. For example, wind abrasion is a problematic idea for students (Dove, 1998) because it is the weathering of rock due to wind erosion (or wind carrying broken rock fragments) causing a sandblasting effect. As these processes closely overlap and/or occur simultaneously, they appear difficult for students and teachers to differentiate. Hence, it is important for teachers to differentiate clearly between the concepts of weathering, erosion, and deposition, and to discuss how the processes most often depend on one another to occur.

Dove (1997) also noted that the term “weather” being located within “weathering” confused students. Elementary children are often taught to identify root words to help infer the meaning of the whole word. Therefore, weathering typically is associated with those situations where rock is moved due to weather, like wind erosion. Conversely, weathering processes that have nothing to do with weather, such chemical weathering due to plant decay acids, were misclassified as erosion. Dove suggests that these misconceptions maybe caused or perpetuated by teachers and textbooks who attempt to simplify the processes for younger students and present both weathering and erosion concepts as one. He noted that both elementary and secondary textbooks commonly made attempts to simplify the definitions of these two concepts, which resulted in misleading information.

Humans in geoscience processes

The final group of misconception research findings that researchers found involved the role of humans in geoscience processes. As this study took place in urban environments, the understanding of students' misconceptions involving human influence is important. Many studies reveal that students confuse natural and man-made materials. Happs (1982, as cited in Dove, 1998) found that while brick was easily recognized, only one in three realized brick did not occur naturally, reasoning that it contained natural materials, so it was a rock. Conversely, he found that polished marble was not commonly considered a rock, because of its shine, which made it appear human-made not naturally occurring (Happs, 1985, as cited in Dove, 1998). Similarly, both children and adults were found to apply the term 'rock' indiscriminately to rocks, minerals, and man-made materials (Dove, 1996), or were found to consider rock material found in buildings and other human constructed areas as 'stone' and different from rock (Ford, 2003).

Before this section concludes its discussion on geoscience misconception research, there is one study that merits special discussion, as it most closely aligns with and informs this dissertation. Ford's (2003) survey of sixth graders' conceptions of rocks in their local environments is important precisely because it focuses on students' immediate environments. In this study, Ford conducted a survey of fifty-five sixth graders at a suburban elementary school for their understanding of rock formation and local rocks. The survey, which included five open-ended free response questions, was administered after the students had completed a geology unit in class. She found that students knew about the major types of rocks and how they typically formed. However, the middle schoolers exhibited a lack of understanding about metamorphosis in rocks and had very little understanding of the conditions of formation and geologic history of the rocks they identified in their local environments. In her discussion section, Ford noted that, "contrary to what I expected, students were readily able to identify rocks in their local, rock-poor environment" (p. 376). That said, while most students located rocks in their urban environment, the majority of rocks were not naturally occurring in the locations where students found them, like construction sites or city gardens. Few students recognized the imported nature of these rocks, and few considered the original environment or origin location of the rock. Implications of this research for urban geoscience education are that teachers need to explicitly cover human altering and transportation of rock, and the importance of considering where rocks originated with students. Additionally, teachers should consider how use of rock examples from students urban environments can provide not only useful samples for class work, but also strong connections between geoscience and urban students' everyday lives. It is the process and extent of these connections by urban elementary schoolers in geoscience education that this dissertation study investigated.

Urban Geoscience Education

Within the larger group of geoscience educators, there is a subgroup of researchers who are specifically interested in urban geoscience education. This group recognizes that slightly more than 80% of the American population live in urban areas (Harnik & Ross, 2004) and wants to create geoscience education that meets the needs of urban students. While the approaches and audiences of research vary, urban geoscience tends to focus on using “content associated with the built environment” (Abolins, 2004, p. 405), and urban geoscience educators are interested in researching the use of this content in educational settings to meet the needs of different audiences. Additionally, they tend to share two common beliefs. First, they believe that geoscience education centered around the urban environment serves urban residents better than traditional geoscience education (Abolins, 2004). Constructivist ideas support the beliefs about the importance of the learner’s environment and experience. Constructivism is a theory of knowledge acquisition that relies on the individual coming to knowledge in a personal and subjective way. Constructivism views knowledge as “personally constructed but socially-mediated” (Tobin & Tippins, 1993, p. 6). Therefore, as it relates to urban geoscience education, constructivist teaching and learning must connect geoscience concepts to the urban environment. Further, urban geoscience educators believe teaching geoscience in K-20 urban classrooms in a fashion that relates to students’ immediate environments will encourage ethnic and linguistic minorities’ participation in geoscience. Currently, participation of these groups in geoscience are at chronically low levels (Abolins, 2004), as indicated by the number of ethnic and linguistic minorities who choose to pursue geoscience degrees and careers.

Urban geoscience education seeks to address two main teaching and learning issues. First, there is a common misconception that in order to learn about geoscience, students must leave developed, human-influenced areas and study “nature”. Pardi and associates (2004) note a “bias on the part of teachers against the built environment and in favor of what is perceived to be a natural environment " (p. 411). Second, they hope to overcome a perceived disconnect between urban students and nature. Many urban teachers express the belief that urban students live in isolation from the natural world, and are often contrasted with rural students who are seen as being surrounded by nature (Harnik & Ross, 2004). This disconnect is noted by both teachers and researchers and is said to lessen student engagement and impede geoscience learning (Birnbaum, 2004; Harnik & Ross, 2004). Additionally, it is of concern that given this disconnect, teachers in K-20 urban environments are not doing more to improve to provide engaging and connecting geoscience experiences to their urban students.

The nature of education in urban areas has caused urban geoscience educators and researchers to show there is a vast amount of geoscience knowledge to be learned by studying urban areas. Topics included in urban geoscience include urban human-environment interactions (Barstow & Yazijian, 2004), urban water quality and supply (Barstow & Haddad, 2002; Bodzin, 2008; O’Connell, Ortiz, & Morrison, 2004; Pardi, et al., 2004), and urbanization (Abolins, 2004; Barstow & Haddad, 2002). Also, urban geoscience educators frequently use stones in buildings (Guertin, 2005; Kean, Posnanski, Wisniewski, & Lundberg, 2004; Kemp, 1992; Wetzel, 2002), cemetery headstones (Endreny & Siegel, 2009; Haywick, Yokel, & Wedgeworth, 2004), local parks (Barstow & Haddad, 2002) and urban gardens (Fusco, 2001) to teach about various geoscience topics including mineral identification to rock weathering. However, there is certainly more work to be done, and as “urbanization continues, studies are needed that detail effective strategies for teaching geoscience in an urban context” (Harnik & Ross, 2004, p. 420).

Urban Elementary Geoscience Education

Of specific interest to my chosen topic of study is the research on elementary urban geoscience education. Since this is such a specialized sub-set of multiple larger areas of research, this section focuses on six research articles which incorporated all of these variables. These articles propose only two ways to include urban geoscience in the elementary curriculum that they deem pedagogically appropriate. One suggests using analogies, and the other five suggest using local fieldwork.

Practitioner journals commonly paint analogies as an effective way to engage elementary students in earth science content (Bhattacharyya & Czeck, 2004; Nottis, 1999; Passey, Cerling, & Chan, 2006; Tolley & Richmond, 2003; Winstanley & Francek, 2004). However, there is a paucity of research on the use of analogies in elementary geoscience teaching and learning. The exception is Blake (2004), who conducted an experimental study in England to explore how sixty inner-city elementary students (aged 9-11 years) understood rocks and how this understanding was influenced by using the instructional analogy of aluminum can recycling. Blake chose this analogy because the students in the study were familiar with the concept of recycling aluminum cans, having completed a project on pollution the previous year. The quantitative data found that students who were taught about the rock cycle using the analogy showed statistically significant gains in multiple areas. However, some children who were taught without the analogy did better than those in the with-analogy group, which “may indicate that providing children with the analogy was not essential for, or even guaranteed, a better understanding of the rock cycle" (Blake, 2004, p. 1868). Blake's further interview data show that the analogy may not have worked because there were "no analogous attributes in the source (aluminum can recycling) that corresponded to metamorphic, sedimentary or igneous processes", but that students did show a "more general understanding that *all* rocks were formed by recycling within the rock cycle framework itself" (p. 1870).

Researchers most commonly suggested use of local parks, waterways, cemeteries, gardens, and roadways to incorporate urban geoscience into urban elementary classrooms. Harnik and Ross (2004) took fifth grade students to a local, urban park a few blocks from their elementary school. Students collected all kinds of natural specimens, like rocks, twigs, and leaves, both in the park and on the walk. They created a label for each specimen that included the locality information. Back in the classroom, students were asked to classify their specimen in scientific and non-scientific ways. They also mapped the areas on a local city map where their objects were located and discussed why the location was important information to include. Once they were classified, the specimens were used in follow-up class sessions. In the final class sessions, the fifth graders created a small classroom museum with their labeled specimen and gave younger students classroom museum tours. This idea is particularly useful in urban geoscience education, as a classroom museum showcasing geoscience specimens found in the community by previous students would be an engaging and meaningful year-round display for students to enjoy and explore.

Harnik and Ross (2004) argue that using local examples connects the science content to students' lives and increases student confidence as it allows them to draw on their previous experiences. Further, they explain that through the process of collecting specimens in an urban area, students collected pieces of man-made materials, like concrete and brick, which appeared rock-like. However, the authors decided rather than "invalidating these finds as somehow outside the focus of natural history" (p. 422), they incorporated discussions on the natural origins of man-made objects. They also noted that this decision caused both the students and teachers to recognize the connections to geoscience presented by examining building stone, gravel, cement and asphalt. Including conversations like these in urban geoscience teaching is essential to help students connect geoscience concepts with their everyday lives.

Field study is another process used in multiple types of urban locations with urban elementary students to teach geoscience concepts. As a teacher-researcher, Endreny (2010) identified "the science learning opportunities present in the many parks, green spaces and bodies of water that were all walking distance from the schools" in which she taught (p. 501). She examined how students' conceptions changed during a place-based inquiry unit on watersheds. Her respondents were a racial and socio-economically diverse group of thirty-three fifth graders from two classes in an urban, public elementary school in New York, with the majority being African American and qualifying for free and reduced lunch (p. 506). She reported that all students "came to understand that their watershed was part of an urban environment where water drains from the surrounding land into a body of water. Thus, they began to understand how urban land use affects water quality" (p. 501).

In another article on field study, Endreny and Siegel (2009) describe the watershed project along with other urban elementary earth science projects of which Endreny was a part. The authors used multiple field trips to a local cemetery to teach students about the three main rock types and how they weather differently. In the cemetery, they provided students direct instruction on recognizing the most commonly used rocks in the gravestones, including granite, marble, gneiss, limestone, and sandstone. The students then explored noting the effects of weathering over time on the different types of stones, and researching data on rock type and date of death to determine when in time each rock was most commonly used. The authors noted that after these field trips, students were much more prepared to read about rocks and the rock cycle in the classroom and library. Bodzin (2008) also investigated a local watershed - specifically a pond in the schoolyard - as part of an after-school science club for urban fourth graders. Participants conducted a long-term study of the pond using web-based GIS mapping and Google Earth. Results showed that participation improved attitudes toward the environment, including stewardship and responsible behavior.

For schools that did not have bodies of water or cemeteries close by, Endreny and Siegel (2009) created lessons on soil, as they reasoned “it is an earth material that could be present at all schools” (p. 193). Students conducted activities similar to those in non-urban elementary classrooms involving dirt, including observing the dirt for its different parts (organic matter, weathered rocks, etc.), separating the soil using screen sieves, and separating the soil using “mudshakes” (or shaken up soil that separates in layers when mixed with water and left to sit for several days). While the authors do not comment on what made these projects “urban geoscience”, they inferred that it is as the investigations took place using soil from urban school yards.

Several studies in urban geoscience education used snow as a model for sediment in common geologic processes. Rule and Roth (2006) researched the use of snow in teaching earth science concepts to elementary schoolers. In their local area, the city had used a large snowblower to slice and trim 2-3 meter tall snow banks to widen the road surfaces. The “resulting flat faces of these snow banks provided an interesting record of the different snowstorms, sanding/plowing events and homeowner shoveling attempts” (p. 506). The authors used photographs of these snow banks to present stratigraphic concepts to their fourth graders as this provided strong links to the students’ familiar experiences with snow.

Rule’s and Roth’s (2006) project allowed students to develop an understanding of two main principles in stratigraphy, essential to understanding and studying most sedimentary and some metamorphic rocks, especially those located in large outcrops. First, they learned about the Principle of Original Horizontality, which states that due to gravity, sediment from a given time is always deposited in horizontal sheets. Second, they learned about the Principle of Superposition, which states that when observing a sequence of these horizontal layers, the oldest layers are always near the bottom and the newer layers toward the top. Multi-storm snow banks were found to model both of these principles, but with snow instead of sediment. Similarly, the snow banks were seen by students to build following these principles in weeks to months, instead of the vast geologic time needed to produce layered rocks.

Similarly, as Endreny and Siegel (2009) conducted their research in urban elementary schools in New York, they also were able to use snow as a resource that was available at every school. The students dug into large snow banks to create cross sections of the banks. They then were able to observe:

> how the snow and plowed material was more compressed at the bottom of the bank and how snow could easily be moved off the top of the bank. This was used as a model for geologic processes of sedimentation, structural deformation and metamorphism. …The students also took the temperature at various snow depths to learn how snow acts as an insulator and that greater depths have hotter temperatures. (p. 194)

Students also used the process of making snowballs as a model for metamorphism, showing the effects of heat and pressure on compacting the snow. In these research studies, snow was used to teach many geologic concepts that would have been impossible to observe directly and interact with due to the lack of naturally occurring rock outcrops in the urban setting.

Summary

Educators have incorporated urban geoscience education in all levels of education, from elementary to post-secondary learning, in both science and education courses. Amongst all these levels, science educators and researchers suggested field work the most as a way to involve the local urban environment. However, what was defined as “field work”, “local”, and “urban” varied in the literature.

Some researchers connected learning to local objects and places within in the city like buildings (Fazio, 1981; Fazio & Nye, 1980; Hoskin, 2000; Kemp, 1992; Wetzel, 2002), urban gardens and parks (Fusco, 2001; Kean, et al., 2004), and indoor shopping malls (Guertin, 2005). Others had a more expanded view of “local” to include nearby state parks (Birnbaum, 2004) and waterways (Birnbaum, 2004; Hall & Buxton, 2004;

Kean & Enochs, 2001; O'Connell, et al., 2004; Pardi, et al., 2004), which were all outside of the urban center of the city. Still others had an even more expanded view of what "related" to urban life, including use of satellite and aerial photos of urban areas to learn about change in geoscience systems (Barstow & Yazijian, 2004), using distances between stores in a nearby outdoor shopping area as a model for the geologic timeline (Haywick, et al., 2004), and use of a curriculum unit on Arctic climate change, encouraging students to infer how this current event might affect cities and city life (Davies, 2006). A major critique of these research studies is that the researchers defined "local" in ways that are not local enough to be truly connected to the learner's lives. For this reason, I encourage researchers to use a place-based framework in designing and conducting studies such as this one.

Conceptual Framework

Choosing a Place-Based Conceptual Framework

Based on the work of Calabrese Barton (2001), Hall and Buxton (2004), and Sobel (2004), the further instruction deviates from students' everyday lives, the less relevant the connections their teachers make are going to seem. While students in Los Angeles, as city-dwellers, may be more likely to be able to relate to geoscience data from New York, another large city, than to data from rural Idaho, it seems an even better solution to give them data from LA itself, as for those students that is their "local, urban" context. In fact, even resources and examples located in the same city as urban learners fail to provide adequate connections if they are not experienced normally by the students. Calabrese Barton (2001) explains:

> Although a visit to a city park, zoo, or cultural center may only be a bus ride away, the barriers are great. For example, several upper elementary youth with whom I had worked had lived only eight blocks from New York City's

> Central Park, yet they had never visited the park with their friends, school, or family. (p. 903)

Therefore, it is important to focus not on students' local contexts, but rather their immediate and lived contexts.

The work of Hall and Buxton (2004) with preservice teachers in New Orleans further supports this argument. As part of a new program aimed at training preservice teachers for success in urban schools, four courses (three content and one methods) were designed to center around the local Lake Ponchartrain. The teachers assumed that since the lake was in the New Orleans area, the elementary students in urban classrooms with which these preservice teachers were working would be interested and engaged. However, as one teacher reflected in her journal, after teaching multiple lessons based on the Lake Ponchartrain curriculum they developed, this was not the case. She wrote that while she used to think she really knew what kids would find interesting, and she spent a whole weekend collecting wetland plant samples from the lake for the class to make a dichotomous key and guide to the plants. However, "they hated it". Instead, this teacher noted:

> The things that we connected to the truly local – their playground, their neighborhood were the best received. To us, the wetlands where we collected the plant samples are local because they're just like ten miles from here, but to these kids, they might as well have been in the next state. When you say make it locally relevant, I'm learning that you mean really local! (p. 343)

This vignette highlights the importance of using "truly local" elementary urban geoscience examples and experiences. It also highlights why place-based education is a viable conceptual framework to investigate how urban elementary students identify, describe, and make connections between earth science as it is taught in school and how they find it in their everyday lives.

Place-Based Education

> Why are we using textbooks that focus on landforms in Arizona when we have such amazing resources in our own backyard?

- Katie Avery, 3rd grade teacher, Gorham, NH (Sobel, 2004, p. 4)

The question posed by the teacher in Sobel's (2004) study is an important one, and mirrors the wonderings which guide this study. Furthermore, it illustrates why place-based education (PBE) is such an appealing framework for this research. Mrs. Avery was teaching third grade geography in a small town in the White Mountains and realized that while she was spending class time teaching about landforms in other states, many children in her class had never even been out hiking on the mountains edging their schoolyard. She identified a great local teaching resource and changed her curriculum to focus on the way the content was seen in the students' environment.

This approach represents place-based education, which is defined as

> the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences.... [It] converts the activist plaint of Not in My Backyard (NIMBY) to Please in my Backyard (PIMBY). Please in my Backyard means that schooling should start out the back door with a focus on the neighborhood. (Sobel, 2004, p. 7)

PBE is supported by the National Science Education Standards (NRC, 1996), as Science Program Standard B requires that "science for all students should be developmentally appropriate, interesting, and relevant to student's lives" and "emphasize understanding natural phenomenon and science-related social issues that students encounter in everyday life" (pp. 212-213).

Critical to PBE are the ideas of space, place, and sense of place. Place is differentiated from space, as place is socially constructed and local while space is quantitatively described and universal. It is for this reason that “people make places out of space” (Semken, 2005, p. 149). Sense of place refers to the meaning and attachments to places held by individuals or groups, and may include “aesthetic, ceremonial, economic, familial, historical, political, and spiritual, as well as scientific” meanings for one specific place (Semken & Freeman, 2008, p. 1043).

Science educators suggest place-based teaching methods and strategies as an alternative to current science teaching practices thought to isolate and standardize science instruction from the lives of the learner (Aikenhead, et al., 2006; Barab, et al., 2007; Endreny, 2010; Gruenewald, 2003; Semken & Freeman, 2008; Sobel, 2004). As discussed earlier, a good deal of research on improving engagement and retention in science of members of indigenous or historically colonized/inhabited communities (e.g., Native Americans, Alaskan Natives, Native Hawaiians, African Natives) uses a place-based framework to help integrate the rich cultural roots of the people/places with the canonical science content (Bevier, et al., 1997; Chinn, 2007; Dubiel, 1997; Glasson, Frykholm, Mhango, & Phiri, 2006; Murray, 1997; Riggs, 2005; Semken, 2005; Semken & Freeman, 2008; Semken & Morgan, 1997).

While much of this geoscience PBE research inspires this study, it is also important to recognize the central differences between PBE work with aboriginal/indigenous populations and PBE work with urban, inner-city populations. Semken (2005) notes that developing PBE geoscience “may be relatively easy in places where students share a common cultural heritage and attachments to the land” (p. 154), but urban environments are distinguished as having multiple cultures existing in one area and urban populations typically lack a common attachment to their neighborhoods.

Additionally, there is currently little research on how PBE geoscience works in a more ethnically heterogeneous environment. Therefore, this study is one of the first to bring PBE geoscience into the field of urban education, and to begin the process of researching how PBE works with more heterogeneous populations.

Other factors potentially limiting the success of PBE geoscience's inclusion in the urban classroom include textbook issues, canonical conflicts, and conflicts with standards-based schooling. Sobel (2004) explains:

> Generic textbooks designed for the big markets of California and Texas provide the same homogenized, un-nutritious diet as all those fast-food places on the strip. State-mandated curriculum and high-stakes tests put everyone on the same page on the same day and discourage an attention to significant nearby learning opportunities. (p. 4)

In researching how urban ecology was pictured in environmental science textbooks, Sullivan (2008) found that most of the pictures of environmental and ecological concepts were shown outside of urban contexts, and of the few that were included, they were in chapters on urban ecology. As these sections tended be near the end of the book, it is uncertain if students in an ecology class using these texts would reach the sections on urban ecology before the school year ended, which could potentially cause a further disconnect for urban students. He argued that textbooks should use more photographs of the science concepts as they occur in urban environments, and include them alongside the desert and rainforest images to help eliminate the common misconception that humans are apart from nature, as discussed earlier, and encourage urban students to see their cities as functioning ecosystems. While there has been no similar study of geoscience concepts in textbooks, a common critique in geoscience articles is the presentation and illustration of geoscience concepts using "the most current, dynamic, or photogenic phenomena culled from around the Earth and other planets" (Semken, 2005, p. 150).

Researchers have also discussed the premises of PBE as potentially conflicting with the current standards and testing driven school system (Aikenhead, et al., 2006; Chinn, 2007; Gruenewald, 2003). Current science education practices emphasize standardizing curriculum to promote success on standardized state, national, and international assessments (such as the TIMMS), which results in curriculum becoming more uniform and devaluing local knowledge and experience (Chinn, 2007). These current trends, as Nell Noddings (2005) notes, promote a generic education for "anywhere", but easily deteriorates into an education for "nowhere".

However, an emerging body of scholarly research shows that PBE has the potential to improve student learning in multiple ways, including increased student achievement in GPA (Lieberman & Hoody, 1998), increased scores on state assessments (Emekauwa, 2004), improved problem-solving and critical thinking skills (Ernst & Monroe, 2004; Lieberman & Hoody, 1998), improved student attendance (Falco, 2004), reduced student discipline issues (Lieberman & Hoody, 1998), increased enthusiasm and engagement in learning (Duffin, Powers, Tremblay, & Program Evaluation and Educational Research (PEER) Associates, 2004; Lieberman & Hoody, 1998), and improved instructional practice in teachers (Duffin, et al., 2004). PBE thus calls for education to not only come from "somewhere", but from the somewhere specific to the learner's immediate environment, and leads to numerous positive outcomes in the process.

In research aimed at including PBE in schools, emphasis is on training teachers to enact PB science teaching in their schools (Chinn, 2007; Dubiel, 1997). Aikenhead and associates (2006) refer to this goal as preparing teachers to be “local experts” and “cultural translators” (pp. 408, 413). This goal is well-suited in places where the teacher has the cultural and local knowledge to make these connections for students, but my research is in response to situations where teachers do not necessarily have the cultural or local knowledge to act as experts or translators. Currently, there is little research on allowing the students to act as “local experts” or “cultural translators” for their own places. This study sought to fill that gap by using a place-based framework to investigate how urban fifth graders identify, describe, and make connections between formal geoscience as it is taught in school and geoscience concepts and processes in their everyday lives.

Conclusions

With science education focusing strongly on promoting equitable science learning for all students and a U.S. population largely centered in urban areas (Atwater, et al., 1995; Buxton, 2006; Calabrese Barton, et al., 2008; Griffiard & Wandersee, 1999; Hewson, et al., 2001), research aimed at informing urban science education is at a premium. Science educators in urban schools face a number of important considerations, with the most commonly cited being large populations of poverty and ethnic minorities, as well as lack of resources and low student achievement. To most successfully promote equitable science learning in urban areas, many science education researchers suggest ways to make science more accessible to all students, specifically by connecting formal science learning to students’ lives. While these connections can be established in multiple ways, this research sought to focus on congruence between school and community. That is, my work aligns with science researchers (Bouillon & Gomez, 2001; Hogan & Corey, 2001; Lee & Fradd, 1998; Lee & Luykx, 2006; Moje, et al., 2001) who seek ways to provide ease in transitioning back and forth between science in school and science as it exists in students' everyday life.

Within the field of geoscience education, research has largely focused on students' conceptions and misconceptions of geoscience content and processes, including geologic time, Earth's layers, soil, rocks, weathering, erosion, and the role of humans in geoscience processes. Focusing on research teaching geoscience in urban environments, urban geoscience educators believe science instruction focused in and about urban living is essential for urban students to engage and make meaningful connections with scientific knowledge. Facing a common belief that the built-world of urban environments is unnatural and that urban students are disconnected from nature, urban geoscience educators seek to show how geoscience education is, and should be taught as, connected to urban students' lives. Using field-work and out-of-classroom explorations of city buildings, gravestones, sidewalks, utilities, parks, and gardens, urban geoscience researchers show how these connections can be made by K-20 teachers.

At the intersection of urban science and geoscience education, research on urban elementary geoscience education, while limited, shows the continued focus on using real-world, urban experiences to connect with elementary science learners. While out-of-classroom explorations were the dominant way these connections were created, they were completely teacher-driven and chosen. This research sought to investigate how urban elementary students themselves make connections between the geoscience content as taught in their classroom and the geoscience concepts and processes found in their daily lives. Using a place-based framework, this work has generated a theory explaining how urban students' personal connections between in and out of school geoscience. The findings of this research have the potential to help inform curricular decisions, especially in situations where the teacher lacks local, cultural knowledge about the content she is teaching, such as in urban environments.

Performing the Search

Four variables limited which literature was included in this review. First, literature on upper elementary schooling (grades three through five) took priority over literature discussing early childhood (pre-K through second grade) or middle school studies (grades six through eight). For this review, studies of high school or post-secondary aged students and their teachers were not included.

Second, within elementary research, only literature on science teaching and learning was included, resulting in the exclusion of literature focused on other elementary subjects like reading, language arts, math, or social studies. Research on both elementary students and/or teachers was included, with teachers encompassing both pre-service and in-service teacher data.

Third, while research on both in-school science and extra-curricular science was included, literature that researched within elementary science classroom contexts took priority. This distinction was made under the assumption that in-school science occurs within the school day and is influenced by state, district, and school-based instructional guidelines (including pacing guides, instructional time, and textbook selection). In-school science is also assumed to be limited to some degree to the state science standards to be taught and assessed. Therefore, the decision making processes and limitations of in-school science are not assumed to be in place in extra-curricular (or after-school) science situations, which most often are both voluntary and not assessed.

Fourth, although practitioner journals are peer-reviewed and contain useful suggestions for teaching and learning in elementary science classrooms, they were not included. Given the empirical research orientation of the following study, this review excludes anecdotal reports of elementary science instruction, because descriptions of studies found in practitioner journal articles typically lack the detail required to analyze and synthesize the studies under review.

CHAPTER 3
RESEARCH METHODS

This study used auto-driven photo elicitation interview collection methods and constructivist grounded theory analysis methods to develop a theory to explain how urban fifth graders describe, identify, and make connections between formal/school earth science concepts and their own everyday lives. This chapter presents the epistemological and methodological frameworks which informed this dissertation. Next, it outlines the study design and provides a detailed description of the data collection and analysis used. It describes how six urban fifth grade participants were observed and interviewed twice throughout their earth science unit. Finally, the chapter concludes with a discussion of my evaluation criteria, my subjectivity statement, and a disclosure of the limitations of my study.

Epistemology and Theoretical Perspectives

The research methods this study was guided by are grounded in a constructivist epistemology. This means that the study reflected interests in uncovering individual constructions of reality regarding an area of interest - in this case, improving urban, elementary earth science. As Hatch (1985) explains, constructivist researchers posit that “knowledge is symbolically constructed and not objective; that understandings of the world are based on conventions, on perceptions held in community with others; that truth is, in fact, what we agree it is” (p. 161). Research within this epistemology does not hold as a desired practice for the researcher to remain distant or objective from their subjects, but instead to engage with them in a construction of their subjective reality regarding the area of investigation (Hatch, 2002).

This study focused on how urban fifth graders describe, identify, and make connections between the formal earth science content they learn in their classrooms and their everyday lives. Because the study focused on how the students acquired Truth and Meaning, which “reside in their objects independently of any consciousness” (Crotty, 1998, p. 42), but rather construct their personal understanding of earth science content, it aligns firmly in the constructivist tradition. The findings are grounded in the complexities of their particular worlds, views, and actions, and emphasize their local worlds and the participants’ distinct and multiple realities. This study assumes that the data on which it is founded were not discovered, but rather were constructed through the interactions between the study participants, their worlds, and the researcher. Second, the study assumes that the theory generated regarding how urban fifth graders describe, identify, and make connections between the formal earth science as they learn it in school and their everyday lives is an interpreted depiction, not an exact representation of the studied and analyzed data. The theory this study generated aims to contribute a useful interpretation of how the study’s participants connect earth science in and out of school, but makes no claim of generalizability across contexts or of discovered, universal, and unchanging Truth.

Research Design

Research Question

The question which guides this study is: How do urban fifth graders describe, identify, and make connections between formal school earth science and their lived experiences?

Research Site Selection

Grade selection

In Florida's Next Generation Sunshine State Standards (NGSSS) (Florida Department of Education, 2008), the earth science content requirements are located in Big Idea #6, "Earth Structures". This big idea is included in the standards for grades 1-4, with the majority of the earth science content being designated for second and fourth grades. However, due to the nature of state-wide accountability testing in Florida, since the science FCAT is administered to elementary school students only in fifth grade, it is in fifth grade where I have personally observed that a considerable amount of science instruction takes place. Additionally, because participation in the research study required students to generate photographic discussion prompts on their own and to explain metacognitively the reasons they photographed the examples of earth science they identified between the first and second individual interviews, fifth grade students seemed most likely to exhibit the level of maturity required for engagement in this research process.

Research setting

To assist in the selection of an appropriate research setting, the district's elementary science coordinator recommended Eagle Elementary, a pre-K-5 school, which is located in and zoned to pull from an impoverished neighborhood within a large urban city in Central Florida. The coordinator recommended Eagle Elementary based on the following discriminating guidelines: (a) the school's principal was known to allow research to be conducted in her school; (b) the school's fifth grade science teacher was known to teach science "well" and was willing to allow the study to be carried out in his classroom.

Eagle Elementary's school population was 98% African American, compared to a 23% statewide average at the time data collection occurred. Additionally, 90% of the students at Eagle Elementary were eligible for the national free or reduced-price lunch program, a noted measure of poverty, while the state average was 46%. Furthermore, the majority of Eagle students came from two impoverished communities of mostly low-rent, single family homes. Combined, these factors combined easily classify Eagle Elementary as an urban school of color and of poverty at the time data collection occurred. On the state standardized tests given the previous year, fifth graders at Eagle scored below the state average in every category. Notably, their lowest category was science, with only 25% of Eagle fifth graders passing the science test compared to the state average of 49% passing (Florida Department of Education, 2009). The fifth grade had four homerooms and four teachers. Students rotated among the homeroom teachers' classrooms each day to receive instruction in each of their subjects, with each class lasting fifty (50) minutes. This study took place in Mr. E.'s (pseudonym) classroom, who was Eagle Elementary's science teacher.

Cooperating classroom teacher

While this study focused on urban fifth graders as the population to investigate, as minors within a school setting, they are often inaccessible except through the gatekeepers that are entrusted with their safety and well-being during school hours. Because classroom teachers are the adults with whom children typically have the greatest at-school interaction, having a cordial working relationship students' classroom teachers is essential when conducting school-based research. Though this study did not focus on Mr. E, it is important to note briefly his role in assisting this research. As a fifth grade teacher who had planned to teach the earth science unit of study at the beginning of the school year and who had agreed to host this study in his classroom, he had satisfied already two important study expectations.

This study set the following additional expectations for Mr. E.: (a) to allow access to his students in order to explain the study and to recruit participants; (b) to receive and hold signed parental consent documents as they returned until collected; (c) to collaborate in selecting interview times and locations during school hours that least interfered with the study participants' learning (i.e., specials, breaks, free time, etc.); and (d) to allow both observations of his teaching during the earth science instruction unit and classroom circulation to provide assistance and build rapport with potential study participants during these times. With the approval of both Mr. E. and the school's principal to host the study in Mr. E.'s classroom secured, the school district gave its final approval for the study to proceed.

Participant selection

The process of selecting student participants began with all students in the teacher's science classes being eligible and receiving consent packets. These packets contained a letter to the parent/guardian explaining the project and requesting their child's involvement, a consent letter for the parent/guardian to sign and return to school with the child, and a copy of the assent letter the students were to sign during the first group meeting if they assented to participate. All students received these packets on the initial observation day, which got them excited to participate by addressing what participation would mean for them (i.e., ability to share their thoughts to help improve their school, time with the camera collecting data, and in the end a gift certificate for their participation). Several researchers note this step of generating excitement around the research and returning signed consent forms as an important step to have success when conducting research with children (Barker & Weller, 2003; Freeman & Mathison, 2009).

In order to increase the number and timely return of signed forms, students were provided the incentive of a piece of candy if they returned their signed form within two days. At the end of the third day of observation, forty-seven (47) students returned signed consent forms, which created a pool of potential participants. Purposeful sampling (Patton, 2002; Stake, 2007) guided participant selection in order to create a group of respondents who were likely to generate as wide a variety of insights into the phenomenon being investigated (Jones, Torres, & Arminio, 2006). Specifically, student's academic achievement, high level of interest in the project, and likelihood of being present for the entire duration of data collection constituted important factors in participant selection, which Mr. E provided as part of his guidance in participant selection. The design of this selection process allowed bringing in as many possible student perspectives as the topic would allow within the context in which the study took place.

One final component of selecting the six participants was getting an additional layer of teacher approval from all four of Eagle Elementary's fifth grade teachers for participants to miss up to a total of three hours of class time over the period of data collection. Scheduling of these missed class hours took place so as to ensure student participants' academic success would not suffer as a result of missed class time during the interview sessions. All four of Eagle Elementary's fifth grade teachers were very understanding and accommodating, requiring only that students not miss class time during FCAT preparation times and days.

Participant descriptions

All students' names used in this study were students' self-selected pseudonyms, a process which increased students' agency and engagement in the study. Six (n=6) fifth grade students from Eagle Elementary participated in this study, and were selected from each of the school's four homerooms. Jamiah and Derek came from the science teacher's homeroom. Butterfly came from the mathematics teacher's homeroom. Fred came from the social studies teacher's homeroom. Finally, Man-Man and Courtney came from the language arts teacher's homeroom. However, all took science classes with Mr. E., Eagle Elementary's fifth grade science teacher.

Jamiah was the youngest participant in this study being 10 years, 1 month at the time of data collection. Having been homeschooled for first and fourth grade, and sent to a private religious school for second and third grade, this was her first year attending Eagle Elementary, as well as her first year in public school. As such, she did not have any previous standardized test scores to designate her academic achievement, but her teachers unanimously agreed she was one of their most bright and inquisitive students.

Courtney, the next youngest at 10 years, 3 months old, was also new to Eagle Elementary this year, transferring from a neighboring school in the district. She was observed consistently to be a quiet and reserved participant in both classroom and non-class interactions. The oldest child with three younger brothers, Courtney was observed to be a care-taker both in and after school, not only for her brothers, but also for her table mates. If a member of her table was not following directions or lacked supplies, Courtney was the one to get them on the right page or given them a pen without saying a word. At the time of data collection, Courtney's records had not been transferred from her old school, so standardized test scores were not available. Her teachers categorized her as a mid-low to low level learner, but could explain her weak performance.

Fred, the youngest male participant, being 10 years, 5 months at the time of data collection, was also a new to Eagle Elementary starting in fifth grade. He and his family, including mom, little brother, and big sister had lived in New York City until this past summer, when they moved to the area. Coming from out of state, Fred did not have any state test scores to compare to his peers. That year, the school had decided to put all the ESE fifth graders, along with some regular education students, in one homeroom to make providing services easier. While Fred was classified as one of the highest academically positioned fifth graders, he was placed in the fifth grade's ESE homeroom. He said that because of his placement in this homeroom he was regularly bored by the instruction and frustrated by his peers' behavior and distractions.

Butterfly was 10 years, 9 months old during data collection and was observed to be very engaged in school, but very isolated from her peers. She never came to school without being dressed in a completely coordinating and fashionable outfit, including matching earrings, necklace, bracelets, and shoes. She was often observed to be picked on by other fifth graders during lunch and class transitions for her excess weight and bright outfits. However, Butterfly explained that she liked the way she looked and figured the people who mocked her were actually just jealous of her style. Academically, Butterfly was a straight B student who scored on grade level in both reading and math on her fourth grade state standardized tests. Similarly, her teachers categorized her as an average or middle level student.

Derek was also categorized as average or mid-level, and was 10 years, 8 months during data collection. He also scored on grade level in both reading and math on his fourth grade standardized testing and was a B/C student on his report card. Having attended Eagle Elementary since Kindergarten, Derek was well known among the faculty and staff as being “smart, but lacking focus” and “loud and restless”. Fortunately, Mr. E had a strong, personal connection with Derek, who recognized his potential, but also his restless nature. As such, Mr. E consistently chose Derek as the one to leave class and run to the office or another classroom, or to be up and moving as much as possible during the school day.

Man-Man was the oldest participant in this study turning 13 years old at the beginning of data collection. He was so much older due to being retained in Kindergarten and in second grade. Then, when he did not pass third grade, he was granted a “good cause promotion”, so that he would not be retained another year. In second grade, Man-Man was tested for academic aptitude, but did not qualify for ESE services or a 504 plan. He ended fourth grade below grade level in reading and mathematics, and was a straight C student in fifth grade. TOver the course of his participation in this study, Man-Man was one of the most thoughtful and creative participants, seeing connections to things in ways others didn’t.

Data Collection

Grounded theory methods require data collection and analysis to occur simultaneously in order to allow ideas and further questions generated during analysis to be immediately incorporated into remaining data collection (Charmaz, 2006; Denzin & Lincoln, 2005). Therefore, while data collection and data analysis in this study constitute two separate sections in the written report, they occurred simultaneously with data analysis beginning as soon as the first interview was completed (see Figure 3-1 for the calendar of data collection events). This research used individual interviews driven by photo elicitation.

Interviewing children

Individual interviews constituted the primary method of data collection. A semi-structured interview format guided the first interview (see Appendix E). A more open format guided the second interview (see Appendix F), which included the use of auto-driven photo elicitation methods (see below). Avoiding the use of rigidly structured or question-and-answer only interviews aimed to foster an open, supportive dialogue that allowed for the construction of ideas regarding how each respondent connected with the geoscience content in and out of school (Freeman & Mathison, 2009).

While Eder and Fingerson (2003) suggest conducting group interviews as one way to improve interviews with children, individual interviews were best suited for collecting rich data addressing this study's research question. Although the study is broadly constructivist in its epistemological foundation, because it focuses on students' individual connections-making, individual interviews are epistemologically consistent with a constructivist approach, whereas focus groups would be appropriate for socially constructivist studies (Patton, 2002, pp. 96-97). The individual interviews thus allowed students' ideas and connections to remain distinct from their peers'. This was an important step in collecting rich data, as children who present ideas in group settings often seek consensus rather than depth in their responses (Eder & Fingerson, 2003). Use of individual interviews allowed the research participants to go into depth about their experience connecting geoscience in and out of school, and allowed for an individual perspective on how one student identifies, describes, and makes connections between these two situations (Freeman & Mathison, 2009).

The semi-structured interviews in this research allowed for directed questioning with the flexibility of probing and clarifying the participants' ideas on how they identified, described, and made connections between formal earth science in school and earth science as it occurs in their everyday lives. The research participants participated in two individual interviews. The first interview lasted approximately 40-55 minutes, and the second interview lasted 35-60 minutes. All interviews were digitally audio-recorded and transcribed immediately after they occurred.

The first semi-structured interview (see Appendix E) took place after the research participants had had a full week of classroom instruction in earth science. The interview probed their ideas about (a) what they remembered learning, (b) what interested them and why, (c) what information they had learned or could use in the future and how they might use this information, and (d) what concepts they identified as being related to their everyday lives, and when they made this connection (i.e., while they were learning or afterward). The interview began in a quiet area with a discussion of what we (as researcher and research participants) meant by "earth science", and also focused on the geoscience concepts and processes which were foremost in the participants' thoughts. White paper served to record these ideas, which were displayed within the child's view throughout the remainder of both interviews.

During the second half of the first interview, we left the quiet area and explored the school campus, looking for examples of earth science concepts on the schoolgrounds. The participants received guided practice in photographing instances of earth science which they identified. When students expressed doubt or questioned whether they could photograph particular items for the study, the prompt “Is this earth science?” aided their decision-making process in a fashion which was not leading. The guided practice further satisfied three goals: (1) it acquainted them with use of the camera and provided them opportunities to problem-solve the camera should issues arrive when they independently collected photographs; (2) it gave them practice in taking photographs and journaling their thoughts on the pink sheets in their notebooks; and (3) it promoted student agency, reinforcing that they themselves were in control over what photographs they took, and that there were no wrong photographs to take. As “it cannot be assumed that children and young people are technically competent with any given visual medium just because it is readily available” (Thomson, 2008, p. 12), this guided practice proactively confronted issues that could have arisen during the research participants’ weeklong independent photograph collection period.

The second individual interview (see Appendix F) occurred following the independent photograph collection period, focused on the digital photographs the research participants took. In order to ensure that the second round of individual interviews truly represented students’ ideas, previous research with children taking and discussing their own photographs with adult researchers (Mizen, 2005; Moss, 2001; Schratz & Steiner-Löffler, 1998) informed the second individual interview’s structure and format. A laptop computer served to show the photographs. Questions initially focused on the two or three pictures they chose to focus on, in order to ensure the participants’ “voice” (Furman & Calabrese Barton, 2006) remained central to the conversations.

However, when certain photographs seemed particularly ripe either for discussion or for furthering a participant's idea, the participants discussed these photographs as well.

The role of photo elicitation

Incorporating the use of auto-driven photo elicitation (ADPE) and student-maintained researcher notebooks aimed to lessen the power dynamic of the adult-child relationship during the individual interviews. Banks' (2007) definition of photo-elicitation as "using photographs to invoke comments, memory and discussion in the course of a semi-structured interview" (p. 65) guided this research study. However, this study specifically used "auto-driven" photo-elicitation to emphasize that the pictures on which the interview questions focused are student-generated, not adult or researcher-generated (Clark-Ibáñez, 2008; Freeman & Mathison, 2009). Use of auto-driven photo-elicitation provides "a way to document a world viewed and experienced by the photographer" (Freeman & Mathison, 2009, p. 110). By allowing the research participants to produce pictures and choose what they considered important, the study's design provided a more direct access to answering the proposed research question.

Freeman and Mathison (2009) argue that using photographs in interviews with children is "helpful to build rapport and to disrupt children's present ideas about one-on-one interactions with adults" (p. 99). Additionally, Thomson (2008) suggests the use of photographs is useful because children and young people are interested in images (e.g., photographs, drawings, cartoons, and multimedia) and because their lives are already "image-saturated" (p. 11). Therefore, using photo elicitation methods with children and young people can provide researchers with a useful vehicle to gain and maintain their participants' interest and engagement. In the case of this research study, the research participants demonstrated considerable levels of excitement in working with photographic images of earth science content.

However, the use of ADPE methods in research with children has the potential to do so much more. It enables students to have an active role in the research process and gives them agency in producing knowledge. It allows them to have their "voice" heard regarding their perspectives and their participation in educational research (Furman & Calabrese Barton, 2006). It provides child research participants the ability to disrupt power relations in the researcher-researched relationship by requiring that research be done *with* them as opposed *to* them (Lodge, 2009; Thomson, 2008). The child research participants' intimate involvement with the process promotes critical dialogue, empowerment, and metacognition regarding decision-making (Freeman & Mathison, 2009). By giving them the flexibility and freedom to choose what is important, what to depict, and how to depict it, the child participants provided a unique source of data which granted "a way to document a world viewed and experienced by the photographer" (Freeman & Mathison, 2009, p. 110). Thus, the use of ADPE in research with children creates a process unlike others in which the research participants themselves truly participate at each stage of data collection - from the taking of the photographs, the photograph selection process, and finally the discussions centered around their photographic work. Because this study used ADPE methods, it ensured that the research participants' voice (Furman & Calabrese Barton, 2006) remained central in the collection process. Furthermore, when the research participants expressed doubt whether they could take photographs of particular items, instead of affirming or negating their choices, the question "Is this a picture of earth science?"

ensured the students maintained their central role in photograph generation. Not only did this ensure they retained their voice (Furman & Calabrese Barton, 2006), it continued to disrupt the researcher-researched power dynamic, providing the participants a greater role in knowledge generation.

Each research participant received a digital camera with which they took photographs for one week, after they had completed the first week of their earth science unit. During the first individual interviews, each participant had guided practice and instruction on camera use, as well as directions to take at least 10 different pictures which answered the following question: “Where do you find earth science in your life?” As a guiding reminder, each camera had this question taped to it. The use of auto-driven photo elicitation allowed the research participants to photograph where they saw earth science in their lives, and then framed a conversation around the pictures they took and why they took them during the second individual interview. By giving the research participants a small notebook, the students were able to journal their thinking processes while they were taking their photographs. Fifteen pages - three pink and twelve white - contained three preprinted boxes each, containing prompts which served to guide their journaling. These prompts were: (1) What is this a picture of? (2) Where did you take this picture? and (3) Why did you take this picture? What earth science idea does it show? These notebooks intended for the research participants to be metacognitive about their photographing. While the students’ notebooks themselves did not constitute part of the analyzed data set in this study, they did help students recall the reasons they took particular photographs and this information was useful during the second interview.

Data Analysis

Because this study was guided by a constructivist epistemology, it used constructivist grounded theory analysis methods (Charmaz, 2003, 2005, 2006). Consistent with the requirements of grounded theory analysis methods, data analysis began immediately after the first interview was complete. Analysis occurred concurrently with the entire period of data collection and continued well after the period of data collection had ended.

Charmaz states that “constructivists study *how* – and sometimes *why* – participants construct meanings and actions in specific situations” (Charmaz, 2006, p. 130; emphases in original). This analysis sought to generate a theory of how fifth-grade urban students identify, describe, and make connections between school-based earth science concepts and earth science in their everyday lives. Beyond the “what” (in terms of what examples they find and connections they make), it also generated a theory of “how” and possibly also “why” the student participants chose those examples and made those connections. For example, Jamiah made a connection using the analogy that bread in the rain is like mechanical weathering. She explained that she had left bread pieces outside for the birds to eat and when she came home later that day, it had rained and the rainfall caused the bread to break-down and apart. She saw what had happened to the bread because of the rain and made the connection that this is similar to what rain does to rocks (i.e., breaking off small pieces until it is gone), but at a much quicker rate than rocks weather. This example gave support to the portion of my theory that suggested students made indirect connections using analogies when they were unable to directly observe the earth science concept.

Coding

Data analysis involved various levels of qualitative coding, or “naming segments of data with a label that simultaneously categorizes, summarizes, and accounts for each piece of data” (Charmaz, 2006, p. 43). Coding allowed for the development of a nuanced and detailed understanding which deeply questioned what the research participants were saying and meaning about how they identified, described, and made connections with the earth science concepts and processes. Coding also enabled the regrouping of ideas participants voiced in the interviews in a coherent theory, allowing for the construction of an answer to the question of how urban elementary schoolers make connections between earth science in and out of school.

Initial coding. The first stage of coding was initial coding, which is the process of studying “fragments of data – words, lines, segments, and incidents – closely for their analytic import” (Charmaz, 2006, p. 42). During this phase, the goal was to explore all the theoretical directions and possibilities that can be discerned from the data. Coding all data on a line-by-line basis helped to identify the student participants’ explicit statements of where they identified earth science concepts, but also some of their underlying conceptions, concerns, and questions about how what they were finding (e.g., concrete and cement) fit into the field of earth science.

Additionally, beginning with the first interview, coding each line of data generated questions and probes to include in the second individual interviews. For example, after a first-pass at initial coding the students’ initial interviews, students seemed to demonstrate misconceptions about the weathering of man-altered materials (i.e., concrete, brick, clay). Therefore, when students returned with pictures of man-altered materials, I made sure to probe this specific topic, which allowed for a deeper investigation of the extent of the confusion around the role of the man-altered materials.

Focused coding. After initial coding on paper, the use of the "free node" function in NVivo 8 allowed for the creation of focused codes. Focused codes use "the most significant or frequent initial codes to sort, synthesize, integrate, and organize large amounts of data" (Charmaz, 2006, p. 46). The initial codes that seemed to make the most sense as categories for sorting data elements judiciously served as focused codes. The goal of this process was to create rough categories for condensing and sorting the data. This allowed for the comparison of the six research participants' ideas and experiences. For example, after all initial interviews received a complete set of initial codes, I put all portions of the transcript relating to direct observation of an earth science concept into one free node, representing one focused code. The focused codes changed actively and remained open to any ideas that emerged when comparing codes across participant responses or when seeking to include all relevant data into at least one focused code (see Figure 3-1 for a chart on the focusing of initial codes into focused codes).

Theoretical coding. After all of the initial codes had been sorted into the focused codes that suited them best, the "tree node" function of NVivo 8 assisted in the generation of theoretical codes, which served to tell both a coherent analytical story of the data and to move these data toward theory building. These "tree nodes" allowed for the sorting of data into relevant subcategories and the probing of links between the ideas the categories represented.

The process of concept mapping, also referred to as diagramming (Clarke, 2003, 2005) assisted in this stage of data analysis and provided a visual representation of the categories and their relationships (Charmaz, 2006), which more completely fleshed out each of the categories, subcategories, and links between categories/subcategories. Various concept maps (see Figure 3-2 for a sample research concept map) provided a permeable boundary between focused and theoretical coding, which moved data analysis toward defining the possible relationships between categories developed during focused coding. Moving between focused and theoretical codes ensured data analysis and theory development gained both refinement and clarity. For example, while I had initially coded each indirect connection as the earth science concept of the IC (i.e., IC – erosion), during focused coding all of these “IC” codes were combined in one “indirect connections” focused code. Then, I realized that it was more useful to answer my research question to look at the ICs in terms of the type of analogy used instead of separating ICs by earth science topic. Therefore, I went back into my focused codes and re-divided all of the initial codes with in “indirect connections” to be labeled as the type of analogy (e.g., appearance, structure, response/behavior), which then generated supporting evidence for my elaborated theory.

Memo-writing

Good grounded theory requires a strong commitment to extensive, spontaneous memo-writing throughout the entire process. Memo-writing served to keep a running record of my thoughts as I went through the data collection and analysis process. Furthermore, this practice provided “a space and place for exploration and discovery” (Charmaz, 2006, p. 82). Memo-writing provided necessary time to engage in a category and to explore whatever ideas emerged. Memos were not added into the data set for analysis, but were maintained separately to help in writing about the research process. I kept my memos using Microsoft OneNote, a note-taking and information-management program. OneNote assisted in keeping the memos organized by date of writing, and also provided a searchable database of all my memos. This proved very useful when reflecting back on the process, and while writing the research findings article (Chapter 4) and the practitioner-oriented article (Chapter 5).

Evaluation Criteria

Due to the nature of the research question and design, I have chosen to use Charmaz' (2005) evaluation criteria for grounded theory studies serve as the evaluation standards for this study. These are (1) credibility, (2) originality, (3) resonance, and (4) usefulness. These criteria align with the tenets of a constructivist epistemology and have been developed as essential components in high quality studies using constructivist grounded theory analysis methods. What follows is an elaboration on the components of the criteria as outlined by Charmaz and how this study satisfies each.

Credibility

In order for research to be credible it must first show that the researcher "achieved intimate familiarity with the setting or topic" (Charmaz, 2005, p. 528). In this study, classroom observations during the taught earth science unit constituted an important non-data portion of this study, and time spent in other non-classroom settings (i.e. lunchroom, playground, after-school activities) provided this intimate familiarity, allowing for an acute awareness of study participants and their learning environment. Prolonged engagement in the setting met a second requirement of credible research: that "data [are] sufficient to merit the researcher's claims" (Charmaz, 2005, p. 528).

Originality

To meet Charmaz' criteria for originality, the categories coded should be fresh and offer new insights, and the analysis should render the data in a conceptually new fashion (Charmaz, 2006). As this study possibly represents the first research using photo elicitation (particularly auto-driven photo elicitation) with elementary students in urban science education, the constructed initial, focused, and theoretical codes as well as memos and constructed theory offer original insights and new ways of understanding how students make connections between formal school science concepts and their appearance in the world outside of school.

To further ensure the study's originality, Charmaz (2005) argues that the work should have social and theoretical significance, and that it should both present challenges and work to extend or refine existing notions and practices. This study meets these criteria by furthering current ideas on how to achieve high-quality urban, science education reform, as well as theoretical ideas on the use of photo-elicitation with children in educational research.

Resonance

Charmaz' (2006) criterion of resonance includes requirements for the author to provide a deep and full portrayal of the participants' experience and to establish connections between the participants' experiences and broader social institutions. Using purposeful data collection and analysis methods, including Charmaz' ideas on mapping as part of the memoing process during theoretical code construction, was particularly helpful in meeting this requirement of resonance.

Resonance also calls for the grounded theory to offer research participants' deeper insights about their lived experiences. Additionally, the grounded theory should make sense to the participants or others who might share their experiences (Charmaz, 2006). As this study's grounded theory developed over the course of the research, I constantly elaborated on and refined this theory throughout all stages of collection and analysis. Additionally, disseminating the findings of this research study, through both researcher-oriented and practitioner-oriented publications (see Chapters 4 and 5) with all interested individuals will satisfy the criterion of resonance meet this criterion.

Usefulness

Sharing the findings of this research study also satisfies Charmaz' (2006) category of usefulness. This study offers data interpretations which science teacher educators, science education researchers, and elementary classroom science teachers can use in their everyday worlds. Chapter 4, which is written as a researcher-oriented article, is structured to meet the publications requirements of the *Journal of Research in Science Teaching*. Chapter 5, which is written as a practitioner-oriented article, is structured to meet the publication requirements of *Science and Children*, the NSTA's publication for elementary classroom teachers, and helps to bridge the existing gap between science education research and elementary science classroom practices. Furthermore, this study's findings and its use of auto-driven photo elicitation have the potential to encourage researchers in other areas of science education to spark further research, such as examining more closely both the nature of students' connections-making and the impact of their connections-making on their understanding (Charmaz, 2005).

Subjectivity Statement

As a former fifth grade urban classroom science teacher of students of color and of poverty, I personally experienced difficulty in creating interest around earth science instruction. My students’ science textbook and my own personal experiences caused me to rely on traditionally used earth science examples in teaching earth science content. For example, when teaching about wind erosion, I discussed sand movement on the beach. When teaching water erosion, I discussed how the Grand Canyon was created. However, many of my students had never gone to the beach or the Grand Canyon, and as such never had the opportunities to experience these traditionally used examples firsthand. This disconnect resulted in my students having difficulty coming to a personal understanding of the earth science concepts I taught them.

My response to this problem was to try to recreate the experience for my students through the use of models. I created models of beach erosion in plastic tubs, and I took my students on a virtual Grand Canyon tour using our SMARTboard. However, the use of these models was still problematic, in that it continued to value traditionally used earth science examples, rather than my students’ real world experiences. In retrospect, I realize that instead of trying to recreate these classic examples through the use of models, I would have been better off connecting the content to my students’ immediate and real world environments. Had I taken them out to see what happens where the storm drains hit the dirt outside our classroom, they would have had a real world, everyday connection to the formal earth science content I was attempting to teach.

Being aware of the impact of my own previous experience with this problem on data collection, I wrote a copious amount of memos to account for my subjectivity. Memo-writing has been suggested as one way to ensure reflexivity and provide a written record of the rationale behind decisions made at each step of the research process (Gasson, 2004). I used my memo-writing as a place to acknowledge and analyze where my insights came from (i.e., the data vs. previous literature or my own experience) and to question why I decided to follow the lines of inquiry I chose.

Limitations

There are several limitations to my study. They include: (a) the breadth and depth of earth science; (b) the temporal scope of data collection; and (c) respondent selection exclusions. The first possible limitation to my study relates to the breadth and depth of earth science. Because fifth graders in the county where this study took place have only 2-3 weeks dedicated to earth science instruction, it is impossible for them conceivably to cover all of the content and process concepts within this field of science. The definition of earth science in this study is as it is understood by each respondent and emphasized by his or her teacher. Therefore, the earth science topics which were not covered in class and/or known to the students cannot be included as possible concepts to which students can relate or which students can identify in their lives.

The second limitation involves the temporal scope of data collection. The choice to limit data collection to student interviews in school to the period during and immediately after the earth science unit of instruction only provided a portion of the earth science instruction the students received in their lifetime. Research participants may have mentioned earth science concepts they had learned previously during the interviews, but I had immediate access only to their fifth grade experiences and the ideas related thereto.

A third limitation involves exclusion criteria used during respondent selection. The choice to select participants who were able to miss up to three hours of time during the school day without fear of their academic success being negatively affected by missed class time may have limited the pool of potential research participants. This requirement acted as a limitation for the study to include students with frequent mandatory pull-outs or by students who are academically unable to miss class time.

Summary

This study used constructivist grounded theory analysis methods to investigate how urban fifth graders describe, identify, and make connections between formal/school earth science concepts and their own everyday lives. Through concurrent data collection and analysis, this research sought to provide a theory explaining how these students relate earth science topics to their lives as well as where they identify examples of those concepts in their lives.

Data collection occurred in the three weeks the county assigned for earth science instruction, which fell during the first nine-weeks of the school year. All fifth grade students at Eagle Elementary received invitations to participate in the study. Of those who returned complete consent and assent forms, six were purposefully chosen to participate. Their demographic diversity, their high level of interest in the project, and their likelihood of being present for the entire three weeks of data collection served as discriminating selection factors. Individual interviews supported by auto-driven photo elicitation provided the data sources for this study.

Data analysis began as soon as the first interview was complete, and informed continued data collection. All data were initially coded after transcription, after which all interviews formed my combined data set for further coding and theory building. Following evaluation procedures suggested by Charmaz (2006), the research yielded findings that will help inform classroom practice, practical and theoretical research in earth science, and use of visual methodologies with children.

~ September & October 2010 ~

Monday	Tuesday	Wednesday	Thursday	Friday
20 Intro Ch. 9 Vocabulary	**21** Earth's Layers	**22** No Block II - Testing Workbook p. 88A	**23** No Rotation - Testing Whole Group Mtg and Mapping Activity	**24** Volcanoes
27 Earthquakes and Plate Techtonics	**28** Weathering	**29** No Rotation - Testing Individual Interviews #1	**30** No Rotation - Boot Camp Individual Interviews #1	**1** Weathering and Soil
4 Erosion	**5** No Rotation - Guest Visitor	**6** Rock Cycle	**7** Rock Cycle	**8** Rock Cycle
11 Chapter Review	**12** Test Individual Interviews #2	**13** Individual Interviews #2	**14**	**15**

Key
Schedule Adjustments
Class Topic
Research Event

Figure 3-1. Data collection event calendar.

Preliminary Analysis During Data Collection

Wrote reflective field notes
Wrote reflective memos
Read transcripts line-by-line and holistically

↓ Coded all transcripts in NVivo 8 ↓

Examples of Initial Codes

Cement a rock
No non-rocks in class
Directly observed on own
Weathering non-rock
IC - Earth's layers
Concrete a rock
Minerals direct observation
Road/asphalt a rock
Principals need earth science
Human erosion
Soil direct observation

Cement - how it's made
Identify non-rocks in situ
No non-rocks in textbook
Directly observed from others
Cement type of rock - sedimentary
Not in real life
IC - mechanical weathering
Where earth science happens
Volunteers need earth science

Questions about non-rocks
Okay with not knowing
Rock vs. non-rock
Brick - how it's made
Erosion non-rock
Teachers need earth science
IC - continental crust
Human impacts
Textbook authors need earth science
Erosion direct observation
Students need earth science
Human deposition

Parents need earth science to help kids with homework
Directly observed from class/text/teacher
Mechanical weathering direct observation
Like in science
IC - volcano
Concrete - How it's made
Exploring on own
Earth science jobs
Human weathering
Likes direct observation
IC - earthquake

↓ Wrote reflective memos; grouped related codes into focused code categories ↓

Direct Observation	Indirect Connections (IC)	Man-Altered Materials (MAMs)
Directly observed on own	IC - volcano	Cement a rock
Directly observed from others	IC - earthquake	Concrete a rock
Directly observed from class/text/teacher	IC - Earth's layers	Road/asphalt a rock
Erosion direct observation	IC - continental crust	Cement type of rock - igneous
Exploring on own	IC - hurricane/tornado	Cement type of rock - sedimentary
Likes direct observation	IC - mechanical weathering	Brick - How it's made
Soil direct observation	Structure analogies	Cement/Concrete - How it's made
Minerals direct observation	Response analogies	Road - How it's made
Decaying matter direct observation	Appearance analogies	Questions about non-rocks
		Okay with not knowing
		Rock vs. non-rock
		Weathering non-rock
		Erosion of non-rock
		Human impacts

↓↑ Reflective memoing; transitioned between focused codes and theoretical codes ↑↓

Students make the most viable connections to concepts they had (or could) directly observe in their everyday lives.	**When DO isn't possible, students make ICs to the concept using analogies of concepts they have directly observed.**	**Students experience confusion and disconnect between rocks taught in class and MAMs they see in their everyday lives**

Figure 3-2. Stages of constructivist grounded theory analysis, with codes.

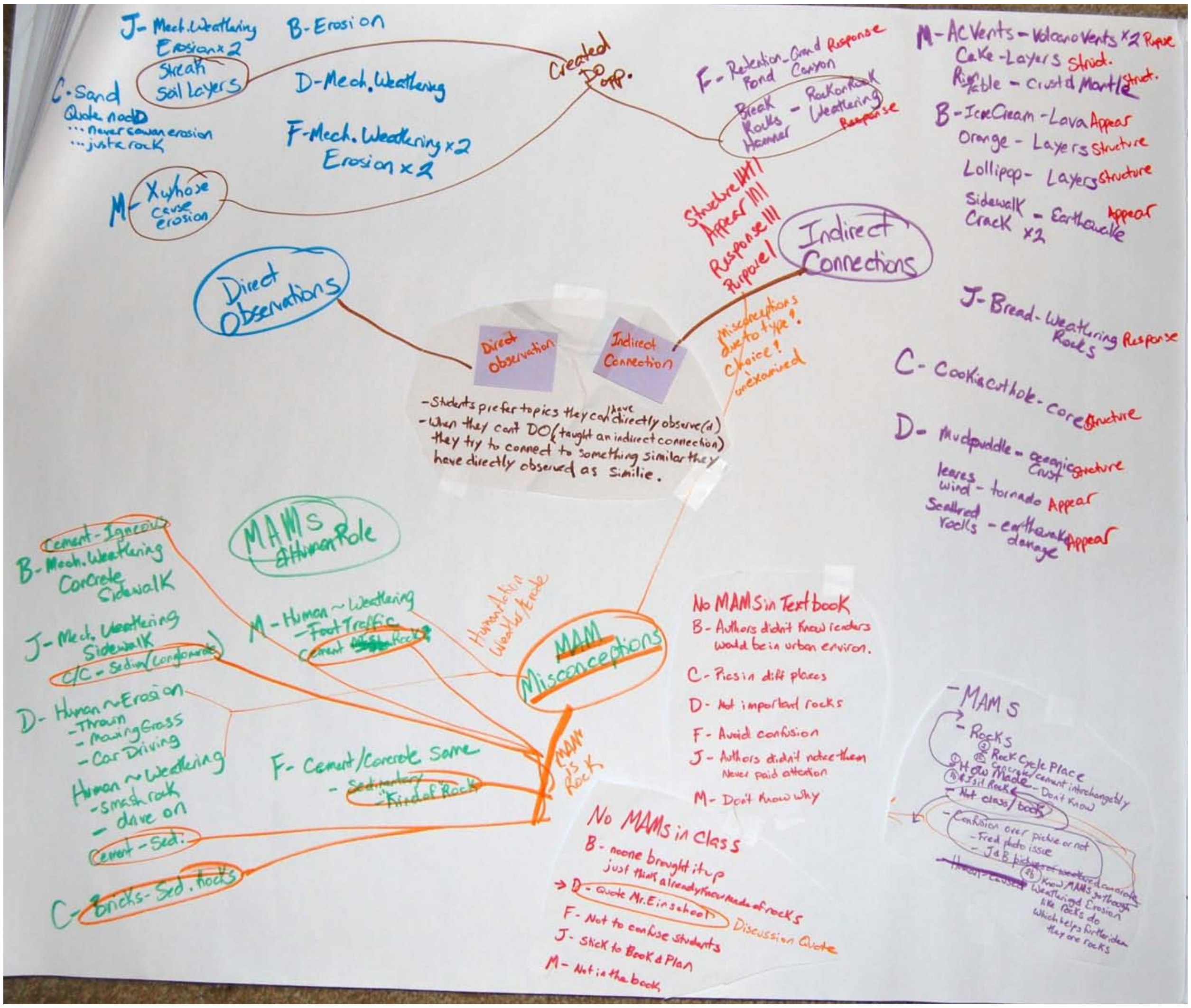


Figure 3-3. Sample concept map.

CHAPTER 4
ARTICLE 1 - URBAN FIFTH GRADERS' CONNECTIONS-MAKING BETWEEN FORMAL EARTH SCIENCE CONTENT AND THEIR LIVED EXPERIENCES

Students come to school with rudimentary understandings and representations of the phenomena that science explains. "These representations are constructed, communicated, and validated within everyday culture... [and] evolve as individuals live within a culture" (Driver, et al., 1994, p. 11). Naive representations of such phenomena are often times very different from the way they are taught and explained in the science classroom. Embracing the learning theory of constructivism, that meaningful learning occurs when the learner is able to make connections to past experiences, such disconnects can make science learning difficult (Lee & Fradd, 1998; Parsons, 2008; Warren, et al., 2001). The teacher choosing to include artifacts, examples, and resources familiar to students can remedy these disconnects (Lee, et al., 2008). However, before a teacher can decide which artifacts, examples, or resources to use in connections-making when teaching a certain science topic for a certain group of students, she must first seek to understand what the possible connections are between the scientific phenomena and children's lived experiences (Lee, et al., 2008).

The current situation nationwide shows that while our nation's schools grow more diverse, the teaching force is much less diverse, leading to a situation in many classrooms where the teachers are not able to connect the content to their students' everyday lives. These differences would not be as important to note, were it not for the achievement gap that exists along racial/ethnic dividing lines in our country. National achievement gaps have been noted for national reading, mathematics, and science scores between White and Black and White and Hispanic students (Grigg, Lauko, & Brockway, 2006; *National Assessment of Educational Progress (NAEP): Mathematics* *assessments*, 2005; *National Assessment of Educational Progress (NAEP): Reading assessments*, 2005). Focusing on the science data, on the 2005 NAEP science assessment, fourth-grade minorities and lower-income students made significant gains and the gaps between White and Black and White and Hispanic students narrowed (Grigg, et al., 2006, p. 6). However, on a test with a total of 300 possible points, there was still a 33-point gap between White and Black students' scores, and a 28-point gap between White and Hispanic students' scores (Grigg, et al., 2006, p. 8). Therefore, while there is room for optimism, there is still a significant gap (9-11%) to be eliminated.

Taken as a whole, this situation presents a problem. The US has a large number of classrooms in high-poverty, urban, elementary schools with white, middle-class teachers. These teachers may not have the life experiences to be able to connect the science content they teach to the lives of their high-poverty, urban students. This disconnect between everyday ways of knowing and scientific ways of knowing has been cited as a potential cause of the science achievement gaps noted for many marginalized groups and making the science "connect" has been one common suggestion to confront this problem (Bouillon & Gomez, 2001; Calabrese Barton, 2001; Calabrese Barton & Tobin, 2001; Fusco, 2001; Settlage & Southerland, 2007; Tobin, 2005; Warren, et al., 2001).

Many science educators call for school science to connect to the lives of the students. For example, Lee and associates (2008), after investigating the science learning of culturally and linguistically diverse elementary students from six schools in a large urban area, called for teachers "to use cultural artifacts, examples, analogies, and community resources that are familiar to students to make science relevant and intelligible to them" (p. 728). Also, Bouillon and Gomez (2001) found, when researching fifth grade urban students, that by learning about ecosystems using a nearby river the students demonstrated a deeper understanding of ecosystem science and an understanding of the nature of science as it applied to a local context. However, while multiple research studies have been conducted on the benefits of connecting science with students' lives, within the field of earth science education there is little research on how elementary students make connections between the formal earth science concepts taught in school and the earth science concepts that they identify in their lives outside of the classroom.

Purpose of Study and Research Question

Finding ways to make formal earth science connect more easily to urban students' lives therefore is of considerable importance. While multiple research studies have been conducted on the benefits of connecting science with urban students' lives (e.g., Calabrese Barton, 2001; Calabrese Barton & Tobin, 2001; Tobin, 2005; Tobin, et al., 2001), researchers have conducted minimal work on connecting geoscience with students' lives. Additionally problematic, this work connects primarily with the lived experiences of indigenous populations (e.g., Bevier, et al., 1997; Murray, 1997; Riggs, 2005; Semken, 2005; Semken & Morgan, 1997), and not the lived experiences of urban students of color and of poverty.

Given this hole in the research literature, and the importance of making geoscience education more personal and more relevant to urban students of color and of poverty, this study explored how urban fifth graders describe, identify, and make connections between formal earth science concepts as they are taught in school and where they appear in their everyday lives. Given the previously discussed disconnect between the lived experiences of teachers and students, this study explored how urban students themselves act as “local experts” and “cultural translators” of their own experiences (Aikenhead, et al., 2006, pp. 408, 413). By understanding how students develop cognitive links between formal earth science concepts and where they see them in their everyday lives, this research will enable classroom teachers - who may be disconnected from their students’ experiences on grounds of race, ethnicity, or socioeconomic status - to create better science learning experiences for their urban students of color and of poverty.

For these reasons, this study sought to answer the research question: How do urban fifth graders describe, identify, and make connections between formal school earth science and their lived experience?

Literature Review

Since the 1990s, scientific literacy has been a noted part of published science education reform documents (AAAS, 1989, 1993; NRC, 1996). These documents rightfully call for science education to provided student-centered, activity-based, quality science instruction for all students at all levels towards the goal of scientific literacy. While the science reform efforts of the AAAS and the NRC were originally welcomed (Calabrese Barton, 2003b, p. 26), they have recently been criticized for promoting a “universalist” view of science, which views the natural world as following a consistent set of rules and a science that should be practiced the same way by all people at all times (Cobern, 1993; Lee & Buxton, 2010; Lee & Luykx, 2006). The problem with a universalist view of science is that it presents science as devoid of culture, as merely existing in the universe, not as a set of ideas developed by humans over the course of our collective existence, failing to recognize how race, culture, ethnicity, language, gender, or other social factors have influenced (and continue to influence) science knowledge and practice (Lee & Buxton, 2010). These documents are additionally criticized for continuing to view the needs of many minorities (e.g., girls, high-poverty, urban students, non-English language learners [ELLs], and racial and cultural minority students) though the deficit model (Lee & Fradd, 1998; Rodriguez, 1997; Roth & Calabrese Barton, 2004; Seiler, 2001).

Science education does not need to be disconnected from the lives of previously marginalized learners however, and could be more accessible for all students, specifically those learners who have been positioned outside of science in the past. These include women (Brickhouse, et al., 2000; Tan & Calabrese Barton, 2008; Topping, 2006), ethnic minorities (Basu & Calabrese Barton, 2007; B. A. Brown, 2006; Calabrese Barton & Yang, 2000; Griffiard & Wandersee, 1999; Kahle, et al., 2000; Yong, 1992), persons from poverty (Calabrese Barton, 1998; Calabrese Barton & Osborne, 2001; Fusco, 2001; Upadhyay, 2006), and urban students (Atwater, et al., 1995; Buxton, 2006; Calabrese Barton, et al., 2008; Griffiard & Wandersee, 1999; Hewson, et al., 2001). Therefore, positioning these previously marginalized learners into science should be a goal of science education, aimed at improving the noted discrepancies between majority and minority groups.

Many urban science education researchers present the idea of science that is related to the students' lives as a key component to promoting equitable learning in science for all students. Some explicitly call for relevant science. For example, Parson's (2008) research on culturally congruent instruction calls for "teaching content via relevant examples" (p. 667). Also, Bouillon's and Gomez's (2001) work on bridging affordances has as a main component that problems chosen were “relevant and of interest to the curriculum and students' lives” (p. 891). Similarly, Tobin, Elmesky, and Seiler (2005) believe students should be “provided with opportunities to learn science in forms that are relevant and significant to everyday life” (p. 310). Others use related ideas like student-centered learning where science is “a collection of topics connected to [student’s] everyday lived experiences” (Seiler, 2001, p. 1007), and congruent third-space which notes the “importance of constructing spaces where students can bring their knowledge and everyday Discourses to bear on science knowledge” (Moje, et al., 2001, p. 492). Though applied to the many fields of science education more generally, these ideas are applicable specifically to geoscience in urban areas.

Geoscience is a field of natural science that studies the composition, structure, and various physical processes of the Earth (and other planets), and Earth's geologic past. It includes studies of Earth’s layers, landforms, water bodies, and atmosphere, as well as human uses of Earth’s naturally occurring resources and the effects of using Earth’s resources on various environments. Within the larger group of geoscience educators, there is a subgroup which is specifically interested in urban geoscience education. This group recognizes that slightly more than 80% of the American population live in urban areas (Harnik & Ross, 2004) and want to create geoscience education that meets the needs of urban students.

While the approaches and audiences of research vary, urban geoscience tends to focus on using “content associated with the built environment” (Abolins, 2004, p. 405), and urban geoscience educators are interested in researching the use of this content in educational settings to meet the needs of different audiences. For example, Wetzel

(2002) used stones in buildings to provide conveniently located rocks for observation. He created a geologic walking tour of downtown St. Petersburg, Florida, for observation by his students. Additionally, urban geoscience educators tend to share two common beliefs. First, they believe that geoscience education centered around the urban environment serves urban residents better than traditional geoscience education (Abolins, 2004). This belief is supported by constructivist ideas about the importance of the learner's environment and experience. Constructivism is an epistemology acquisition that relies on the individual coming to knowledge in a personal and subjective way. Constructivism views knowledge as personally constructed but socially mediated with the learner coming to know in a personal and subjective way. Therefore, as it relates to urban geoscience education, constructivist teaching and learning must connect geoscience concepts to the urban environment. Further, urban geoscience educators believe teaching urban geoscience in K-20 classrooms will encourage ethnic and linguistic minorities' participation in geoscience. Currently, participation of these groups in geoscience are at chronically low levels (Abolins, 2004), as indicated by the number of ethnic and linguistic minorities who choose to pursue geoscience degrees and careers.

Urban geoscience education has been incorporated in all levels of education, from elementary to post-secondary learning, and has been included in both science and education courses. Among all these levels, field work is the most commonly suggested strategy to involve the local urban environment. However, what was defined as "field work", "local", and "urban" seemed to vary among the research. Some of these researchers connect learning to local objects/places within in the city like buildings

(Fazio, 1981; Fazio & Nye, 1980; Hoskin, 2000; Kemp, 1992; Wetzel, 2002), urban gardens and parks (Fusco, 2001; Kean, et al., 2004), and indoor shopping malls (Guertin, 2005). Others had a more expanded view of “local” to include nearby state parks (Birnbaum, 2004) and waterways (Birnbaum, 2004; Hall & Buxton, 2004; Kean & Enochs, 2001; O’Connell, et al., 2004; Pardi, et al., 2004), which were all outside of the urban center of the city. Still others had an even more expanded view of what “related” to urban life, including use of satellite and aerial photos of urban areas to learn about change in geoscience systems (Barstow & Yazijian, 2004), using distances between stores in a nearby outdoor shopping area as a model for the geologic timeline (Haywick, et al., 2004), and use of a curriculum unit on Arctic climate change, encouraging students to infer how this current event might affect cities and city life (Davies, 2006). A major critique of these more expanded views is that the researchers defined “local” in ways that some do not believe are local-enough to be truly connected to the learner’s lives. For this reason, some geoscience educators encourage teachers and researchers to use a place-based education (PBE) framework in designing and conducting lessons or studies in urban environments (Endreny, 2010; Hayden, 1997; Kean & Enochs, 2001; Semken, 2005).

Theoretical Framework

Place-based teaching methods and strategies have been suggested by many science educators as an alternative to current science teaching practices thought to isolate and standardize science instruction from the lives of the learner (Aikenhead, et al., 2006; Barab, et al., 2007; Endreny, 2010; Gruenewald, 2003; Semken & Freeman, 2008; Sobel, 2004).

Place-based education (PBE) is defined as “the process of using the local community and environment as a starting point to teach concepts in language arts, mathematics, social studies, science, and other subjects across the curriculum. Emphasizing hands-on, real-world learning experiences” (Sobel, 2004, p. 7). It is supported by the National Science Education Standards (NRC, 1996) as Science Program Standard B requires that “science for all students should be developmentally appropriate, interesting, and relevant to student’s lives” and that it should “emphasize understanding natural phenomenon and science-related social issues that students encounter in everyday life” (pp. 212-213).

Frameworks for PBE match the national standards for science education. However, when the standards are applied at the state level and science content is assessed using high-stakes standardized accountability tests, the power and effectiveness of PBE are ignored (Aikenhead, et al., 2006; Chinn, 2007; Gruenewald, 2003). Current science education practices emphasize standardizing curriculum to promote success on standardized state, national, and international assessments (such as the TIMMS), which results in curriculum becoming more uniform and devaluing local knowledge and experience (Chinn, 2007). These current trends, as Nell Noddings (2005) notes, promote a generic education for “anywhere”, but easily deteriorates into an education for “nowhere”. For these reasons, PBE advocates argue that grounding students’ learning in the immediately local - a position entirely consistent with constructivist epistemology - will not only avoid this education for nowhere, but also will ensure students make meaningful connections with the content they need to succeed on accountability tests.

An emerging body of scholarly research shows that PBE has the potential to improve student learning in multiple ways, including increased student achievement in grade point average, or GPA (Lieberman & Hoody, 1998), increased scores on state assessments (Emekauwa, 2004), improved problem-solving and critical thinking skills (Ernst & Monroe, 2004; Lieberman & Hoody, 1998), improved student attendance (Falco, 2004), reduced student discipline issues (Lieberman & Hoody, 1998), increased enthusiasm and engagement in learning (Duffin, et al., 2004; Lieberman & Hoody, 1998), and improved instructional practice in teachers (Duffin, et al., 2004). PBE thus calls for education to not only come from “somewhere”, but from the somewhere specific to the learner’s immediate environment, and leads to numerous positive outcomes in the process.

In research aimed at including PBE in schools, emphasis is on training teachers to enact PB science teaching in their schools (Chinn, 2007; Dubiel, 1997). Aikenhead and associates (2006) refer to this goal as preparing teachers to be “local experts” and “cultural translators” (pp. 408, 413). This goal is well-suited in places where the teacher has the cultural and local knowledge to make these connections for students, but my research is in response to situations where teachers do not necessarily have the cultural or local knowledge to act as experts or translators. Currently, there is little research on allowing the students to act as “local experts” or “cultural translators” for their own places. This study sought to fill that gap by using a place-based framework to investigate how urban fifth graders identify, describe, and make connections between formal geoscience as it is taught in school and geoscience concepts and processes in their everyday lives.

Research Setting and Participants

This study was conducted at a preK-5 elementary school, Eagle Elementary, which was located in and zoned to pull from an impoverished, urban neighborhood in a large city in Central Florida. Eagle Elementary's school population was 98% African American, compared to a 23% statewide average at the time data collection occurred. Additionally, 90% of the students at Eagle Elementary were eligible for the national free or reduced-price lunch program, a noted measure of poverty, while the state average was 46%. These factors combined easily classify Eagle Elementary as an urban school of color and of poverty at the time data collection occurred. On the state standardized tests given the previous year, fifth graders at Eagle scored below the state average in every category. Notably, their lowest category was science, with only 25% of Eagle fifth graders passing the science test compared to the state average of 49% passing (Florida Department of Education, 2009). The majority of Eagle students came from two impoverished communities of mostly low-rent, single family homes. The fifth grade had four homerooms and four teachers. Homerooms rotated between teachers each day to receive instruction in each of their subjects, with each class lasting fifty (50) minutes.

My participants were six (n=6) fifth grade students from Eagle Elementary. All students in the class were invited to participate in the study. Of those who returned complete consent and assent forms, six were purposefully chosen (Patton, 2002; Stake, 2007) as my selected respondents. All students' names used in this study were students' self-selected pseudonyms, a process which increased students' agency and engagement in the study. Jamiah and Derek came from the science teacher's homeroom. Butterfly came from the mathematics teacher's homeroom. Fred came from the social studies teacher's homeroom. Finally, Man-Man and Courtney came from the language arts teacher's homeroom. However, all took science classes with Mr. E., Eagle Elementary's fifth grade science teacher. The participants demonstrated varying levels of academic ability. For example, Jamiah and Fred demonstrated consistent success at school, whereas Man-Man was a 13-year-old fifth grader, having been retained twice. These varying ability levels notwithstanding, all participants demonstrated high levels of interest in the project and were judged likely to be present for the entire period of data collection by Mr. E.

Participants and their teacher were observed throughout their earth science unit and interviewed twice over the course of the unit. Data collected involved individual interviews supported by auto-driven photo elicitation. Data collection for this study was done during and following the unit of earth science instruction in the research participants' classroom.

Data Collection Methods

Grounded theory methods require "simultaneous data collection and analysis, with each informing and focusing the other throughout the research process" (Charmaz, 2005, p. 508). Therefore, while data collection and data analysis are listed as two separate sections, they occurred simultaneously. Data analysis began as soon as the first interview was complete, with the aim of focusing all further data collection (Charmaz, 2005).

Auto-Driven Photo Elicitation

Using photographs in interviews with children has been previously noted as "helpful to build rapport and to disrupt children's preset ideas about one-on-one interactions with adults" (Freeman & Mathison, 2009, p. 99). However, in this project it did much more. Use of participant-produced photographs also provided "a way to document a world viewed and experienced by the photographer" (Freeman & Mathison, 2009, p. 110). For my research, I used Banks' (2007) definition of photo-elicitation as "using photographs to invoke comments, memory and discussion in the course of a semi-structured interview" (p. 65). Specifically, I used what is referred to as "auto-driven" photo-elicitation to emphasize that the pictures about which I am asking questions are student-generated, not adult or researcher-generated (Clark-Ibáñez, 2008; Freeman & Mathison, 2009). I was extremely interested in how using the child-produced pictures would allow the respondents to choose what is important and what to depict, providing a more direct access to answering my overall research question.

I provided each of my participants with a digital camera to take and use for one week. They received instructions on camera use and directions to take at least ten (10) different pictures which answer this question: "Where do you find earth science in your life?" As a guiding reminder, this question was printed and taped to the camera. This method allowed the students to photograph where they saw earth science in their lives. These photographs allowed them to frame the conversation, in a follow-up interview, around what they took pictures of and why.

Students were also given a small notebook in which to record notes on what they were thinking about when they chose to take each picture. Use of this notebook was intended to help the student be meta-cognitive about the pictures taken and provided a reminder when asked to explain why the picture was taken in the second individual interview. For example, Jamiah noted that using her notebook caused her to think about why she was taking a picture of a weathered rock and how this rock connected to the earth science concepts she learned in class.

Individual Interviews

The first semi-structured individual interview (see Appendix E) was designed to probe students' ideas about earth science in relation to the following: (a) what they remember learning about; (b) what interested them and why; (c) what information they used (or could use in the future) and how; and (d) what concepts they identified as related to their everyday lives and when they made that identification (during learning or after). The initial interview began with a discussion of what we (as researcher and respondent) meant by earth science as a structuring element and also what geoscience concepts and processes were foremost in the child's thoughts. These ideas, recorded on a white paper, remained displayed within the child's view throughout the first and second interviews with that student.

The second half of the interview took place throughout the school's campus as participants explored and looked for student identified examples of earth science on their schoolgrounds. This part of the process had three main goals: (1) to acquaint the student with use of the camera and how to problem-solve should issues arise while they have it for the week; (2) to give the student practice in taking pictures and recording in their photo-collection journal; and (3) to promote agency in the students that they are in control over what pictures they take and that there is no wrong answer. Even though researchers may assume that children are competent with all forms of technology because this technology is readily available, Thomson (2008) argues this is a false assumption. This is particularly the case for students who may not have access to this technology in their homes. Therefore, the second half of the initial individual interview focused on proactively confronting the issues that could arise during the student's photography week. At the end of the initial interview, participants received a review of directions for their week of photo-collection around the community and answered any questions they had about the process and/or their task for the next week.

In the follow-up individual interview (see Appendix F), which occurred twelve days after the students received the cameras, we looked through the pictures they took using a laptop. We went through the pictures once as an overview of what they took and then went more in depth with individual pictures of either their or my choosing. Questions focused on the two to three pictures they chose to talk about, and others which the researcher identified as particularly ripe for discussion or furthering an idea. Previous research with children taking and discussing their own photographs with adult researchers informed the format of this interview (Mizen, 2005; Moss, 2001; Schratz & Steiner-Löffler, 1998). Students took a total of eighty-eight pictures showing direct and indirect connections to earth science concepts, as well as connections to MAMs and to non-earth science concepts like trees, plants, and clouds (see Table 4-1 for students' photographs by type).

Data Analysis Methods

Data analysis began as soon as the first interview was complete and informed my continued data collection. All data were initially coded after transcription, after which all interviews formed my combined data set for further coding and theory building. Due to the nature of my research questions, Charmaz' (2006) constructivist grounded theory methods guided data analysis. This analysis sought to generate a theory of how fifth-grade urban students identify, describe, and make connections between school-based earth science concepts and earth science in their everyday lives. Beyond the "what" (in terms of what examples they found and connections they made), this study wanted to generate a theory of “how” and possibly also “why” the student participants chose those examples and made those connections.

Analysis began with initial coding, which is the data were analyzed and coded on a line-by-line basis, as this helped to identify the student participants’ explicit statements of where they identify earth science concepts, but also some of their underlying conceptions, concerns, and questions about how what they were finding (e.g., concrete and cement) fit into the field of earth science. Initial coding was done directly onto the data manuscript.

After initial coding, the “free node” function in NVivo 8 served to create focused codes which use “the most significant or frequent initial codes to sort, synthesize, integrate, and organize large amounts of data” (Charmaz, 2006, p. 46). To do this, the initial codes that made the most sense to use as categories guided data sorting judiciously and completely. The goal of this process was the creation of rough categories for condensing and sorting the data, allowing for the comparison of participants’ ideas and experiences. For example, after all initial interviews received a complete set of initial codes, all portions of the transcript relating to direct observation of an earth science concept sorted into one free node. These codes were actively changing and remained open to any ideas that emerged when comparing codes across participant responses or seeking to include all relevant data into at least one focused code.

When this was complete, NVivo’s “tree nodes” function was used to sort data in the largest free nodes into relevant sub-categories and facilitated the establishment of links between the ideas the categories represented (see Figure 3-1). Concept mapping, or diagramming (Clarke, 2003, 2005) in this stage of the analysis provided a “visual representation of categories and their relationships” (Charmaz, 2006, p. 117) in order to more completely flesh out each of the categories, subcategories, and links between categories/subcategories.

Those concept maps served as the permeable boundary between focused and theoretical coding, by which analysis moved toward defining the possible relationships between categories developed during focused coding. Moving back and forth between focused and theoretical codes often ensured data analysis and theory development were getting both significantly refined and clarified (see Figure 3-1). In turn, these concept maps helped develop the model of my theory (see Appendix G), showing how each of the identified important components of students’ connection making were used and where knowledge or opportunity for knowledge was lost.

Findings

The major findings of this dissertation involve the role of direct observation, indirect connections, and man-altered materials in how urban fifth graders identify, describe, and make connections between earth science as it is taught in school and as it exists in their everyday lives. This section will discuss those findings and the theory created to explain their use in how students make connections between earth science in school and in their lived experience.

Direct Observation Connections

Students made the most concrete connections to concepts they had (or could) directly observe in their everyday lives. Also, the majority of the pictures students took showed DO connections (see Table 4-1). Sometimes these direct observations (DOs) occurred in the student’s past and he/she connected the memory to the concept when taught it, but in the majority of examples, the student first learned the concept, then identified and observed it as naturally occurring in their lives outside of school to make a connection. In a few cases, students created a DO through their actions outside of school, which allowed them to observe the concept they had been taught through an exploration of their own creation. Earth science concepts to which students made direct observation connections included streak, soil layers, and sand, but mostly centered on examples of weathering and erosion. Furthermore, the students demonstrated considerable preference for science phenomena they could directly observe.

When students talked about earth science concepts that related or seemed to connect to their lives, some discussed examples where, as they were being taught the concept in class, they remembered directly observing an example of that concept and made a connection between that direct observation and the concept. For example, when Mr. E was teaching a lesson on layers of soil, Jamiah remembered a recent event where her friend was digging in the garden:

> *Interviewer:* Okay. Is there anything, ah, that you've seen lately that made you think of any of these ideas?
>
> *Jamiah:* Not really. Probably, ah, when I went to my friend's house and she was doing gardening.
>
> *I:* Mm-hmm. Tell me about that.
>
> J: The soil was changing colors because she was just digging and digging and digging.
>
> *I:* Okay. So as she dug deeper, you saw different colors of soil.
>
> *J:* Like it was lighter.
>
> *I:* Okay.
>
> *J:* So, then she just did it. I didn't get to see the rest of it.

> *I:* And when you saw her digging and you saw different colors of soil, ah, did you think back to school if whether you had an explanation for that or not or did you not really connect the two until now?
>
> *J:* No, because that was in the past and I didn't really learn about this yet.
>
> *I:* Right. Okay. So the other way around. When you were learning about soil the other day in Mr. E's class, did it make you think about your friend in the garden?
>
> *J:* Yes.
>
> *I:* Okay. And did learning about the topsoil and the subsoil help you understand.
>
> *J:* Yes.

While Jamiah presents an example of creating a connection based on memory of direct observation, the majority of DO connections were made after the concept had been taught in class.

In both sets of interviews, students gave examples of connections they had made based on directly observing a concept that they had recently been taught in school. Some of these connections were teacher initiated, or examples given in class and then observed by students in their lives. For example, when talking about mechanical weathering, Mr. E showed a video on weathering and erosion that showed through illustrations how plant roots grow and break soil. To illustrate the concept of mechanical weathering, he drew a tree growing near a sidewalk on his classroom's whiteboard, and then drew the roots going from below the ground to crack the concrete. Then, in interviews with the students, three of them gave this as a connection they had made. For example, when describing his observation of a big tree in the middle of a cracked sidewalk near an Amway Center, Fred connected his observation to Mr. E.'s whiteboard drawing. In all three of these cases, the students were not just repeating the connection from class, but had gone out after class and observed this teacher initiated example.

In contrast, many of the direct observation connections students gave seemed to have been of their own identification, as shown in the photographs they had taken. All of these connections involved students identifying examples of weathering and erosion after the concepts had been taught. For example, after many days of rain, Derek returned home from a football game and noticed that some of the rocks in his yard had broken while others had remained intact:

> *Derek:* When [the rocks] broke it made me think about mechanical weathering.
>
> *Interviewer:* It did! So, so tell me about that. Tell me about when the rocks broke, was that this weekend?
>
> *D:* It, it was after my football game.
>
> *I:* Okay, and how did it break? How did the rocks break?
>
> *D:* When, when we, when it rained from Monday, Tuesday, and Wednesday, they broke, so some rocks were soft and some were hard. But the soft ones broke.
>
> *I:* Okay, from the rain?
>
> *D:* Mm-hmm.
>
> *I:* Ok, and you decided that was mechanical weathering?
>
> *D:* Mm-hmm.
>
> *I:* Ok, good. Um, so, you, you got home from football and you went into your garden and then you realized that the rocks had broke. Yea?
>
> *D:* (nods)
>
> *I:* And then what went through your mind? When you realized the rocks had broke?
>
> *D:* Mechanical weathering

I: It instantly - it just went across - I know the name for that now.

D: Cause I paid attention and learned what mechanical weathering and chemical weathering is.

Similarly, Fred discussed observing rocks in his backyard weather over time by getting "little cracks in them, like right here (pointing to picture)". He predicted that he did not see the little pieces that broke off anymore, because "they just kind of, like they mix in with the soil." Butterfly also took pictures of man-altered materials that had been weathered and explained that the pieces "washed away" (see Figure 4-1).

Two students went a step further than observing naturally occurring earth science concepts and explored on their own to create direct observations of the concepts after being taught them in class. For example, Jamiah noticed in the book that streak was one way rocks were identified and decided to experiment with rock streak on her own:

Interviewer: How about here, what am I looking at?

Jamiah: That's a streak.

I: All right. How did you make this streak?

J: I got a big rock and I kept on going back and forth on the sidewalk.

I: All right. And so what color was the rock when you started when you looked at it?

J: It was sort of brownish like tannish.

I: Okay. And then when you rubbed it?

J: It turned white for some reason.

I: Okay. Did that surprise you?

J: Yes.

I: So you thought that it would be

J: Brownish.

I: Tan just like the rock, okay.

J: That's why I picked a white surface.

I: Right.

J: But it turned out white.

I: Oh, it's very cool. Do you have any idea why it looks white when you rubbed it but when you look at it in your hand it looked brown?

J: Ah, it's probably because like weathering it probably made the rock change colors and that's its original color.

In this example (see Figure 4-2 for the photograph), Jamiah created a connection to the concept of streak by actually using a rock from her yard and seeing how it streaked on the sidewalk. She explains that the rock was brown, so she predicted that the streak would also be brown, but “it turned out white”. She explains that the reason for this difference in color is probably related to a form of weathering in which the rock changes color.

Indirect Connections

When students were not able to directly observe the concept/phenomenon, they created indirect connections (ICs) between the concept being taught (A) and an example they had directly observed (B). All ICs were made to concepts that the student did not make a direct observation connection to, and this was most often because these concepts did not occur in their everyday lives. Most ICs were made to concepts involving earth’s layers, volcanoes, and earthquakes and were most often presented as analogies (A is like B). Students made indirect connections that were analogous in terms of appearance, structure, and response.

When making indirect connections, two students made linkages between things they had directly observed that looked similar to concepts they were being taught. For example, when Butterfly was talking about volcanoes, she mentioned that when she thinks of lava, she pictures soft serve ice cream when it comes out of the machine. Thus she uses the analogy, lava appears to move the same way as soft serve ice cream. Butterfly also made an appearance-based IC involving earthquake damage as being related to sidewalk cracks and scattered rocks in a yard:

> *Interviewer:* What Earth Science idea did this remind you of?
>
> *Butterfly:* Uhm, there's a earth, an earthquake.
>
> *I:* OK. Tell me why this reminds you of an earthquake?
>
> *B:* That's when a earthquake forms when the earth crust ripped.
>
> *I:* OK. And is that, so tell me what this is a picture of in your own words.
>
> *B:* A un-manmade crack.

Butterfly mentioned this connection three separate times over the course of her two interviews, and chose to take two pictures of sidewalk cracks as representing earthquake damage. Likewise, Derek took a picture of various small rocks unevenly scattered around a spot in his backyard:

> *Interviewer:* Tell me about these rocks. Why did you decide to take a picture of them?
>
> *Derek:* Because it, because it, because it had, because it had something to do with an earthquake.
>
> *I:* An earthquake?
>
> *D:* Uh-huh.
>
> *I:* OK. Why did this make you think of an earthquake?
>
> *D:* Because it's scattered all around.
>
> *I:* OK. And how is that like an earthquake?

> *D:* Well, when an earthquake happens, the whole ground shakes and the rocks come out of place from the garden, I mean, from the dirt, and, and scatters them.
>
> *I:* OK. So do you think that these rocks got scattered by an earthquake or did the way they were scattered just made you think of an earthquake?
>
> *D:* Just it made me think of an earthquake.

Derek further explained that he did not think the rock scattering was caused by an earthquake, but instead the scattered rocks made him think of the appearance of a yard after an earthquake.

Similarly to indirect connections based on appearance, some students made connections to the look of the observed object connecting to the structure of the taught concept. In making connections to the structure of un-observable geosciences concepts, students used some common analogies like bubble-gum filled lollipops being like earth's layers (crust, mantle, core) and "orange peel as the earth's crust". However, they also used some unusual analogies. One example of an unusual structural analogy came from Man-Man, who was discussing connections he made to cracks created in earthquakes:

> *Interviewer:* Earthquake? Uh-huh, what did you relate an earthquake to?
>
> *Man-Man:* Like, like when a earthquake hits the water it like makes a line. And if its a real bad one. It can, like, make another, like, line through the ocean.
>
> *I:* Uh-huh.
>
> *M:* Like open it. So, on that Sunday dinner, my mom would cut the, uh, piece of cake. So, it was like the ocean opening.

While Man-Man had learned about earthquakes that week in class, he noticed when his mother cut into a frosted chocolate cake during Sunday dinner that he could now see what was inside the cake. Recognizing that before the cake was cut, he could only see the surface, he related this cutting and opening of the cake to the way earthquakes often separate land and show what is under the surface of the Earth. Other less common structural analogies used included relating a mud puddle to oceanic crust, and discussing the rim around a circular table as relating to the size differences between the crust and mantle of Earth.

Two students made indirect connections that were analogies based on response, in which the directly observed object responded in the same way to an action as a concept they were learning would respond. For example, during data collection, Fred explored on his own breaking rocks with his hammer. He then talked in his second interview about how breaking rocks with a hammer was “like a hammer, like if a rock is in water and another rock comes and flowed by, like a hammer hitting another rock”, causing them to weather. Fred’s exploration allowed him to connect to the concept of weathering rocks due to water moving other rocks. Similarly, Jamiah had an experience where her actions allowed her to connect to weathering analogously. She explained how she left bread out in her yard for the ants and then observed how the bread broke down when it rained. This direct observation produced the analogy that bread breaks down due to rain like rocks break down due to rain, or bread and rocks respond in similar ways when rain falls.

Man-Altered Materials

Thus far, I have discussed findings relating to students’ direct and indirect connections to naturally occurring earth science concepts and related examples. However, another finding of this research is the role of non-natural, or man-altered materials (MAMs) in the process of students’ connections-making to earth science concepts. The importance of MAMs - such as brick, concrete, asphalt, and tile - in students’ earth science connections is clearly seen when looking at the photographs taken by the students. Of the total number of pictures taken and written about, sixteen included MAMs. Furthermore, every student - without exception - had taken at least one picture of a MAM. This likely resulted because MAMs and their creation were covered neither in class nor in their textbooks. As such, the students did not know to distinguish between rocks and rock-like materials. For example, Fred could not differentiate between cement, the limestone-based powder used to make concrete, and concrete itself. In fact, most student respondents used the terms concrete and cement interchangeably. Furthermore, most students incorrectly expressed the idea that these MAMs were “rocks”, and as such part of the natural rock cycle. Because they observed MAMs going through weathering and erosion like rocks do, this furthered the incorrect idea that they were rocks.

When students brought back pictures that including MAMs, I probed to elicit the students’ understanding of the earth science concepts they depicted. Not one of the students could explain correctly how concrete/cement or roadways are made. Only one of the students, Man-Man, correctly explained that “rocks and concrete is two different things. It's made out of the same thing but we use it for a different resource.” However, earlier in the interview, he had also identified a sidewalk as an igneous rock, because in making them road workers “melt ‘em and flatten it out with no lumps”, after which it “make loosey thing [*sic*]... and as the day goes by, it gets harder and harder”. Therefore, it seems that even Man-Man, like the others, had trouble classifying MAMs.

Two students used the term “fake rock” to explain concrete, but didn’t know how they were made. The other three students explained these MAMs as made of multiple combinations of crystals, rocks, minerals, soil, steel, and paint. For example, when Butterfly returned with multiple pictures of sidewalk cracks, I probed for her understanding of the processes that made that sidewalk. In her explanation, Butterfly reasoned that road workers “mix concrete with gray paint and rocks, and then they pour it and then they let it harden”. From this description, it seemed Butterfly has seen the final stages of creating a sidewalk, but is unaware of what happens previous to this stage. She has imagined that concrete mix is added to gray paint and rocks to make the cement. She later explained that she believed that the concrete was a “rock” and, like Man-Man, thought it was an igneous rock, because it had melted and then re-hardened - characteristics of igneous rocks which they had been taught in class.

Among the students, confusion over where MAMs fit into the three rock categories - sedimentary, igneous, and metamorphic - was common. Three students thought that concrete/cement was a sedimentary rock. For example, when talking about a picture Derek had taken of the road meeting the curb, he incorrectly reasoned that concrete/cement were sedimentary rocks “because sedimentary rocks are settled together”. This logic was also expressed by Fred, who said “I think roads is just like sedimentary rocks but they're smoother because of the cars are always running on them.” Additionally, Jamiah incorrectly identified a chunk of concrete as a “conglomerate”, a type of sedimentary rock the students observed in class.

Serving to further their ideas on MAMs being “rocks” was that every student observed that these materials appear to weather and erode the same way rocks do. In Fred’s quote above, he explains that the roads are “smoother because of the cars”. This was similar to the thoughts of Jamiah, Man-Man, and Derek who all talked about examples of weathering of MAMs produced by human activity, such as driving cars, foot traffic, and deliberately smashing. Derek also discussed examples of ways that human activity can cause erosion of MAMs, such as concrete chunks getting cut up by mowers, cars driving over and pushing pieces toward the curb, and road sweeping. These observations were used as supporting evidence by students that MAMs were indeed “rocks”. However, because the role of MAMs in society was not addressed sufficiently either during class time or in their textbooks, students’ misconceptions that MAMs were rocks remained.

A Constructed Theory

This study sough to explain how a group of urban fifth graders identify, describe, and make connections between earth science as it is taught in class and as it exists in their everyday lives. Findings showed the important roles of direct observation, indirect connections, and man-altered materials in student respondents made connections between earth science in school and out of school. Given the noted importance of these three categories within the data, as well as viewing the data as a whole, this research proposes a theory of how these students used direct observation, indirect connections, and man-altered materials in their process of connection making (see Appendix G for a model of this theory).

This research theorizes that in order for meaningful, scientifically correct connections to be made between earth science in school and as it exists in students' lives outside of school, connections must meet two criteria: a) there must be a way for the concept to connect to their everyday life, and b) the content must be covered, that is addressed either directly or indirectly, in class. When content is within a student’s lived experience and covered in class, students make connections using direct observation and indirect connections using analogies. If content is taught, but not connected to students' lived experiences (ex. continental vs. oceanic crust), it is lost and no meaningful connections are made. If the content is connected to students' lives, but not taught (ex. concrete, cement), then the connections are attempted by students, but create confusion. This confusion can lead to incorrect scientific assumptions (ex. concrete is igneous rock, because it melts then hardens) when not addressed in the curriculum.

Discussion

This study of urban fifth grade students in a high-poverty school sought to generate a theory of how these students identify, describe, and make connections between earth science as it is taught in school and as they find it in their everyday lives. Data analysis showed that the students created connections in three ways. First, students appeared to make the clearest connections with earth science concepts taught in class that they could directly observe in their everyday lives. Second, when students were taught an earth science concept they believed they could not directly observe, they created connections to the concept through use of analogy, which in some cases led to misconceptions. Finally, students commonly made connections to non-rock materials that were altered by humans for use in society, such as concrete or brick. This work theorizes that in order for meaningful, scientifically correct connections to be made between earth science in school and as it exists in students' everyday lives, connections must meet two criteria: a) there must be a way for the concept to connect to their everyday life, and b) the content must be covered to some extent in class or the science curriculum.Students made the clearest connections between earth content taught and examples of that content in their lives outside of school, specifically with examples they could directly observe. This was not surprising, as for many years educators have noted that more effective learning occurs when that learning is connected to direct experiences (Aylesworth, 1963; McNamara & Fowler, 1975; Mullen, 1962; Piaget, 1964). In fact, this concept is a core tenet of constructivist learning.

However, one portion of these findings science education researchers have not noted is that, in addition to creating more effective instruction, students preferred direct interaction and observation of earth science concepts. This preference for direct observation was seen clearly in the way two students went out of their way to create situations in which they could directly observe the phenomenon they had been taught in class. In addition, all student participants mentioned they especially liked cases where they had known of the example as a part of their lives before earth science instruction and then learned the name (or vocabulary word) for what to scientifically call that concept.

When students were unable to make connections to concepts they had directly observed, they made connections using analogies, or indirect connections. The role of analogies in science education has been thoroughly researched (Clement, 1998; Gentner & Gentner, 1983; Heywood, 2002; Heywood & Parker, 1997; Summers, Kruger, & Mant, 1998) and tends to agree that the core purpose of using analogies is to help students understand an abstract phenomena through connections to a concrete, observable phenomenon (Heywood, 2002). It also notes that any explanation of abstract concepts needs to be rooted in students' existing experiences in order for them to accurately interpret the abstract idea (Summers, et al., 1998). This research provides an additional dimension to the literature on the use of analogies, as students themselves created analogies to make sense of the formal earth science concepts they were taught at school which they could not directly observe.

In this study, students wanted to make connections to what they were learning, so much so that they put in the time to develop their own analogies to understand earth science concepts that they were taught, but could not directly experience. Students developed analogies using things they had directly observed that were similar to what they were learning about in terms of appearance, structure, or behavior/response. Of the three types, it seemed the appearance analogies were the least useful for understanding the science concept to which they were trying to connect. This is because while two things may look similar, use of that analogy does not help students understand the relational aspects or causality of the science concept. For example, while soft-serve ice cream coming out of a machine may look like lava coming out of a volcano, there is nothing about understanding the ice cream that helps the student understand the lava. The students' analogies based on structure or response were those that most helped inform their understanding of the science concept. However, as these student-created analogies were not discussed in class, the students were never presented with the need to critically examine the utility or possible limitations of the analogies they created. This teacher supported constant comparison of abstract concept to chosen mental model has been found to be essential to the process where analogies work (Clement, 1998; Heywood & Parker, 1997).

When students were making connections to earth science concepts in their everyday lives, this study found that connections to and confusion over non-natural, or man-altered materials (MAMs), played a significant role in student connection making.

Many in the science education community believe that we teach children science in school in order to help them understand their world and make informed decisions about their place in that world (Aikenhead, et al., 2006; Millar, 1996; Turner, 2008). However, that world is not just the naturally-occurring world. The reality of life in our modern society is that students live in a man-altered world of concrete, brick, glass, and plastics. By only teaching naturally occurring geology and earth science processes in our science classes, textbooks, and standards, we are choosing to not teach students the content that would actually connect to their everyday lives. For many years, earth science instruction has been critiqued as failing to provide a “relevant curriculum” (McNamara & Fowler, 1975, p. 413), with suggestions made that when this type of curriculum is used, teachers fail to teach children how the earth science content can be related to their lives outside of school (Glasser, 1969). More recently, Bransford and Donovan (2005) have argued that science instruction that does not “explicitly address students’ everyday conceptions” (p. 400) typically fail to help students refine or replace their misconceptions with more scientifically accurate conceptions. Despite these suggestions being presented for over forty years, in this study the same situation was found.

All of these findings point to the importance of adopting a framework for place-based education in urban environments when teaching earth science content. Previous research (Seiler, et al., 2001, 2003; Tobin, et al., 1999) has found that good urban science education can work to counter a number of the problems typically seen in urban environments including the effects of tracking, teaching to the test, and student resistance to strictly academic learning. This finding is supported by the findings of this study which found that student participants felt use of place-based geoscience took them away from the textbook and test prep, and created a space for them to interact with the earth science concepts without the strict academic context. Furthermore, elaborating on previous place-based education research on Native American and First Nations Canadian populations (Bevier, et al., 1997; Dubiel, 1997; Murray, 1997; Semken, 2005; Semken & Morgan, 1997; Vierling, et al., 2006), this study suggests that a PBE geoscience curriculum would also help urban, high-poverty elementary learners. However, while this study used a dramatically different population, it found some of the same important qualities in research involving teaching geoscience as that which studies indigenous/native populations (Riggs, 2005). The findings of this research gives support to place-based curricula, specifically use of experiential, outdoor science taking place within the traditional areas where the students were very familiar.

Implications for Science Education

This study's findings emphasize a need for more place-based education, especially in the teaching of earth science in urban environments, because it provides clear connections to students' lives outside of school, an important component of constructivism learning is often not provided in the traditional teaching of earth science. Teachers in urban areas need to adopt place-based educational praxes in order to start bridging the gap between earth science as it is taught and as it occurs in their students' everyday lives. Teacher educators should train inservice and preservice teachers to identify directly observable examples of earth science phenomena on their urban school's grounds and in their neighboring communities. When teaching about weathering and erosion, for example, teachers can have students observe two locations where directed water flow affects the sediment where it is discharged. Students can observe that where rain gutters discharge large amounts of water, large depressions form, but where air conditioning condensers discharge small amounts of condensed water on a day-after-day basis, comparably small depressions form. This simple, cost-free, and immediately local inquiry allows students not only to come to a deeper and more personal understanding of the earth science concepts of weathering and erosion, but also to have the opportunity to discuss this common experience further in whole-class or small group formats.

The indirect connections students made in this study between formal earth science concepts as taught in class and their everyday lives highlight their common use of analogies when attempting to make connections between phenomena they cannot directly observe and their personal experiences. Discussion within inservice professional development and preservice teacher preparation on how to use analogies to deepen students' personal understanding of formal earth science concepts, as well as how to critique these analogies for strengths and weaknesses, may provide classroom teachers with an enlarged instructional skillset applicable to their students' immediate experiences. Teachers can have their students record the personal indirect connections and analogies they make in a science journal, which can serve subsequently as anonymous whole-class prompts for discussion of the related earth science concepts. If a student came to class with the analogy, "Lava moves like soft-serve ice cream coming from an ice cream machine", the classroom teacher could use this analogy anonymously in a whole-class discussion where students would contribute ways that lava is and is not like soft-serve ice cream. This discussion would provide both a review of earth science content related to lava and opportunities to address any potential misconceptions the analogy could generate.

The important role of man-altered materials in how students made connections in this study shows a major disconnect in earth science instruction between what is taught and what is lived. As participants and their teacher did not discuss man-altered materials (MAMs) in class, students assumed they were rocks, developing much confusion on the role these materials play in the rock cycle. Students had trouble additionally with the notion that while humans break and move rocks, neither counts as weathering or erosion. Teachers should supplement their normal earth science curriculum with explorations and discussions to teach that these common man-altered materials are made from rocks, but are no longer called "rocks" because humans and machines have formed them in the place of geologic processes. A teacher could bring in samples of rocks and MAMs and could allow students to observe and discuss which of the samples are "rocks". The teacher additionally could present a scientifically accurate definition of rock, as well as instructions on how common MAMs are made - such as how materials engineers transform limestone rock into concrete. Without this kind of instruction, teachers leave students to make massive intuitive leaps between naturally occurring processes and human ones.

Implications for Science Education Research

Previous studies using a place-based education (PBE) framework for teaching earth science focus primarily on the experiences of indigenous populations (Aikenhead, 2001; Chinn, 2007; Dubiel, 1997). This study's findings demonstrate that urban students of color and of poverty likewise may benefit from place-based earth science instruction in making connections between formal earth science concepts and their lived experiences. Further studies in urban schools of color and of poverty may provide additional depth to the tentative findings this research provides, shedding additional light on the effectiveness of using a PBE framework in increasing urban students' understandings of earth science concepts.

Researchers may also be interested in expanding the scope of this study to include students learning in different educational settings. Exploring the effectiveness of a PBE framework for earth science with urban and suburban middle-to-upper-class students, and with rural students of all socioeconomic status may have a considerable impact on the ways in which students of all backgrounds learn earth science content most effectively.

Researchers finally may want to undertake studies examining whether students' abilities to identify, describe, and make connections between formal earth science concepts and their lived experiences transfers to connections-making in contexts foreign to those students. This consideration has implications which are particularly important regarding high-stakes standardized test items, as existing research (García & Pearson, 1994; Gipps, 1999; Lynch, 2001; Solano-Flores & Nelson-Barber, 2001) demonstrates the effects of cultural bias on students' test performance.

Final Thoughts

All told, this research study contributes new insights to the research community's understanding of science education in the urban elementary classroom. By exploring how urban fifth graders described, identified, and made connections between formal earth science content as it was taught in class and instances of earth science in their everyday lives, this study sheds light on the value of implementing a place-based educational framework in teaching earth science more effectively to students in high-poverty urban schools. Considering the importance of students' abilities to directly observe earth science content in their local environments, of their desire to make sense of earth science concepts they cannot observe directly through the use of analogy, and of the role man-altered materials play in their environments can help deepen urban students' understandings of the content material they learn in class. Opportunities to expand on this research study additionally abound, as science education researchers may seek to examine the effectiveness of place-based education across a variety of contexts and science subjects.

Table 4-1. Breakdown of students' photographs by subject of picture

Participant	Direct observations (DO)	Direct observations of man-altered materials (DOMAM)	Indirect connections (IC)
Butterfly	14	3	0
Courtney	4	3	1
Derek	7	2	0
Fred	6	1	1
Jamiah	11	4	2
Man-Man	3	4	2
Totals	46	16	6

Figure 4-1. Participant-generated photograph of mechanical weathering.

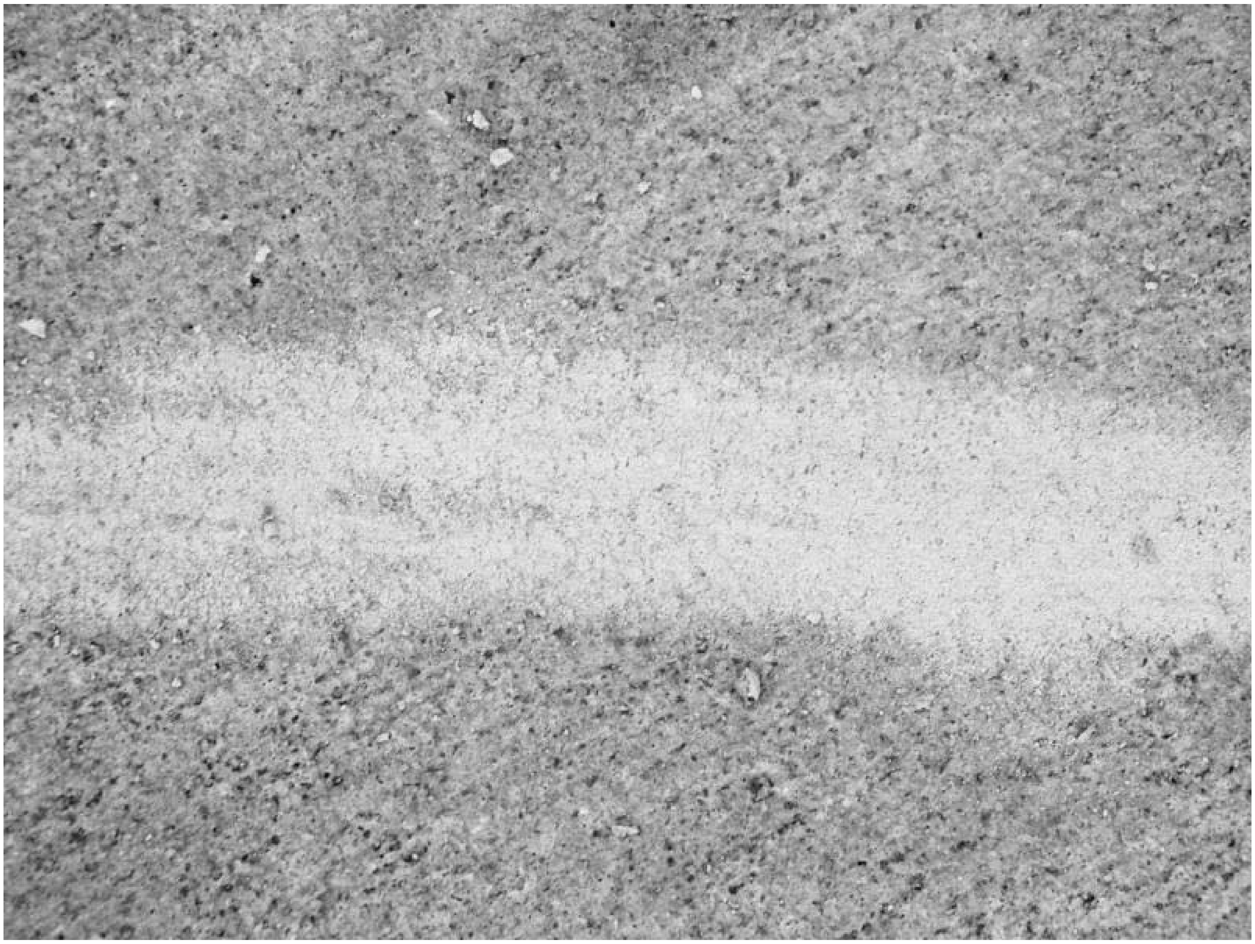


Figure 4-2. Participant-generated photograph of rock streaking.

CHAPTER 5
MOVING THEORY INTO PRACTICE

In the process of taking my research, converting it, and applying it to the creation of an elementary geoscience lesson, I attempted to incorporate my dissertation's findings and theoretical framework with existing research on elementary science education (Bodzin, 2008; Lee & Luykx, 2005; Luykx & Lee, 2007). This constituted an important step in bridging the gap between research and practice, which numerous educators have addressed previously (Korthagen, 2007; Korthagen & Kessels, 1999; Nuthall, 2004; Osterman, 1998). I theorize that in order for students to make useful connections between earth science in school and in their everyday lives, the content must be addressed in class somehow. If not, students will make connections to earth science related examples in their lives, but will not have the necessary scaffolding to make valid, scientifically accurate connections and understandings (see Appendix G). Therefore, I thought it essential to develop a lesson that would allow the role of man-altered materials to be incorporated into the traditional earth science curriculum.

In the initial construction of my lesson, I chose to use a learning cycle, or 5E, approach (Bybee, 2002). The 5E lesson format allows students to have direct experiences with science content before science concepts/vocabulary themselves are explicitly taught. Dewey (1938) argued for the importance of using students' experiences as stepping stones for rigorous academic teaching in all content areas. He stated that "the central problem of an education based upon experience is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences" (pp. 27-28). Using the 5E model therefore provides students with appropriate examples on which students can build subsequent rigorous science content learning.

The first phase of a learning cycle lesson (engage) is designed to tap into students' backgrounds as a way to lead into the science concepts they will investigate during the lesson. This may come in the form of a KWL chart if beginning a new topic or a review of previous activities and ideas that the class has been using. In the case of the lesson I constructed, this took the form of the formative assessment probe, "Is It a Rock?" (see Figure 5-1).

The second phase (explore) provides students the opportunity to interact with the concept guided by a teacher-provided structure. While teachers may provide different levels of structure for different types of inquiry (Barrow, 2006; Martin-Hansen, 2002), during this phase the teacher should always provide some kind of challenge, problem, or question to explore (Settlage & Southerland, 2007). In the lesson I produced, during the explore section students observed samples of various rocks and man-altered materials and provided reasons for which they thought each was either a rock or not a rock. Bringing in the realia provided students with the kind of concrete experience for which Dewey (1938) advocated, and allowed additionally for a common frame of reference. The decision to have students distinguish between rock and rocklike substances came out of my dissertation's research findings - that urban elementary students had difficulties differentiating between rocks and man-altered materials. Furthermore, the decision to have them use a record sheet - a tangible space for students to record their observations and to encourage them to make inferences and predictions - was based on previous research that noted students' memories of exploration activities are stronger when aided by such an aid (Settlage & Southerland, 2007).

The third phase of the learning cycle (explain) has two parts - students explain what they found and the teacher explains the vocabulary and science content students experienced during the explore phase. In my lesson, the teacher began the explain phase by asking for student ideas and reasonings, and then presented students with a video which provided them with information which either supported or rejected their reasonings. This video showed the process of turning limestone rock into cement powder and finally into concrete sidewalks, allowing them to see that while concrete material started as rocks they no longer count as rocks because the limestone has been sufficiently altered by men and machines.

The fourth phase (extend/elaborate) provides students with the opportunity to apply their new understandings to a new situation or application. In this activity, students took their knowledge of how to differentiate between rocks and man-altered materials and extended their thinking to consider if MAMs weather and erode in the same manner as rocks do. Students went outside their classroom onto school grounds to find at least three examples of weathering or erosion of man-altered materials. Students then returned to the classroom to share their findings and reinforce distinctions between rocks and MAMs. The decision to have students leave their classrooms for the extend phase of the lesson was informed by the theoretical framework of place-based education, which argues that students should be given to apply science knowledge to their local familiar contexts (Aikenhead, et al., 2006; Emekauwa, 2004; Endreny, 2010; Sobel, 2004).

The fifth phase (evaluate) occurs concurrently and simultaneously with the other four phases of the 5E lesson. Throughout the previous phases the teacher made ongoing formal and informal assessments of students' learning. At the close of the lesson, the teacher provided students with a summative assessment to inform the students about how their understanding had progressed. To bring closure to this lesson, the formal probe given during the engage phase as both a formative and diagnostic assessment was given again to see how students' ideas had changed as a result of their participation.

Using my dissertation findings as an impetus to develop a practitioner-oriented article was much more difficult than I had anticipated. Cognizant of the theory-practice divide (see Korthagen, 2007; Korthagen & Kessels, 1999), I felt it was important not only to think through the implications of my findings for science instruction, but also to go a step further by doing the mental work necessary to convert these findings and implications into a classroom lesson. Even as the person who knew this dissertation's findings most intimately and as a teacher of the 5E method, changing findings into instruction was not easy. Because science teachers may not have the time necessary to do the mental work in converting research findings into lessons, educational researchers who write practitioner articles to accompany their research not only do teachers a tremendous service but also have a much more direct impact on actual classroom practice. Furthermore, when the classroom teacher who taught this lesson in her fourth grade Texas science class reported that her students initially experienced the same manner of confusion as my urban fifth grade Florida participants, but the lesson had helped them clarify that confusion, I felt as though this created lesson helped bridge the gap between an existing body of research (e.g., Aikenhead, et al., 2006; Semken & Freeman, 2008; Sobel, 2004) and actual classroom practice.

CHAPTER 6
ARTICLE 2 - "IS CONCRETE A ROCK?": MAKING CONNECTIONS BETWEEN EARTH SCIENCE CONTENT AND STUDENTS' EVERYDAY LIVES

To promote equitable science learning, many researchers suggest making science more accessible to all by connecting formal science learning to students' lives. While these connections can be established in multiple ways, much of the research seeks to focus on congruence between school and community (Bouillon & Gomez, 2001; Lee & Fradd, 1998; Lee & Luykx, 2006) and ways to provide ease in transitioning back and forth between science in school and science as it exists in students' everyday lives.

Within the field of geoscience education, research has focused largely on students' content conceptions and misconceptions. This research includes studies of ideas on geologic time (Kusnick, 2002; Trend, 1998), fossil fuels (Rule, 2005), weathering and erosion (Dove, 1997), earth's structure (Lillo, 1994; Sharp, et al., 1995), and rocks (Dove, 1996; Ford, 2005; Hawley, 2002).

One portion of that research has looked specifically at the role of humans and human-altered materials in geoscience teaching and learning. Multiple studies reveal that students confuse natural and man-made materials. Happs (1982) found that while students easily recognized brick, only one in three realized brick did not occur naturally. The others reasoned that because it contained natural materials, it was a rock. Happs (1985) conversely found that polished marble was not commonly considered a rock because of its shine, which made it appear human-made. Similarly, Dove (1996) found both children and adults applied the term 'rock' indiscriminately to rocks, minerals, and man-made materials, and Ford (2003) found they considered rock materials found in buildings and other areas as "stone", different from rock.

Some researchers connected this geoscience learning to local objects/places within city-like buildings (Fazio & Nye, 1980; Hoskin, 2000; Wetzel, 2002), urban gardens and parks (Fusco, 2001), and indoor shopping malls (Guertin, 2005). Others had a more expanded view of “local” to include nearby state parks (Birnbaum, 2004) and waterways (Hall & Buxton, 2004; O'Connell, Ortiz, & Morrison, 2004), all of which were outside of the urban center of the city. One major critique of these research studies is that the researchers defined “local” in ways that were not local enough to be truly connected to the learners’ lives. For this reason, some geosciences educators (Aikenhead, et al., 2006; Barab, et al., 2007; Endreny, 2010; Gruenewald, 2003; Semken & Freeman, 2008; Sobel, 2004) encourage the use of a place-based education (PBE) framework in designing and conducting lessons for urban environments.

Place-based education (PBE) is defined as “the process of using the local community and environment as a starting point to teach concepts” across the curriculum while emphasizing real-world learning experiences (Sobel, 2004, p. 7). It is supported by the National Science Education Standards (National Research Council, 1996), as Science Program Standard B requires that science “should be developmentally appropriate, interesting, and relevant to students’ lives” and should “emphasize understanding natural phenomenon and science-related social issues that students encounter in everyday life” (pp. 212-213).

Research to Practice

In an attempt to transform these research findings into teaching practice, this 5E lesson was designed and taught to fourth grade students at the end of their earth science unit, emphasizing the utility of place-based science in geoscience education.

The goal of this lesson was to meet the National Science Education Standard (K-4) calling for students to be able to “distinguish between natural objects and objects made by humans”. While this standard is usually met during physical and life science lessons, these students did not differentiate between geologically-formed rocks and man-altered materials (concrete, brick, asphalt). Therefore, instruction on distinguishing natural from human-altered materials was needed as part of their earth science curriculum.

Engagement

To begin the lesson, students were given the formative assessment probe “Is It a Rock?” (Keeley, et al., 2007; see Figure 5-1 for a student sample) to engage their thinking and questioning regarding what is and is not a rock, and why. Students were first asked to complete the task individually, but later discussed their ideas in small groups. Some students were not able to identify the names of pretest materials (coral, marble, iron ore), but the teacher did not explain anything to them; she just told them to do their best. If students asked questions, the teacher asked a question back to help guide their thinking without giving answers, and to leave them wondering. After completing the probe, the teacher had several students share their responses along with their reasoning. Most picked dried mud and brick because they are hard and look like rocks.

Exploration

During exploration, the teacher told students that their groups would be receiving some samples of rocks and non-rocks for them to explore. The teacher then passed out the samples (a-g). These samples included: (a) concrete; (b) brick; (c) breccia; (d) quartzite; (e) clay pot; (f) pumice; and (g) faux stone. Students were giving an

“Exploration Table” sheet to collect their observations and thoughts (see Figure 5-2 for a student sample).

Within their groups, students were encouraged to work together to fill in all the boxes on the “Exploration Table”, which set them up to discuss and argue their ideas. At this stage, it was good to have different ideas presented. Students were given twenty (20) minutes within which to examine the samples and to complete their tables. More time would have been useful, but the nature of the “science block” in this situation allowed only twenty minutes of time for student observation. The teacher circulated during this phase, guiding students in making useful observations and encouraging them to use descriptive words. However, the she did not guide students in their decision process, because she wanted them to come to their own reasons and conclusions.

Explanation

After student exploration ended, the teacher engaged the students in a whole group discussion eliciting their observations and their decision-making reasoning . Questions were used to probe students’ thoughts about each of the samples and how they decided on what to call a rock or not. The teacher asked students for ideas and then asked for other students’ alternative ideas . She then informed students what the name for each sample was (i.e., a = Concrete, b = Brick) and encouraged students to take notes on the back on their Exploration Table, which would then go in their science notebooks. Once students knew which of the samples were and were not rock, the scientific definition of a rock was established as: A rock is an indefinite mixture of naturally occurring substances, mainly minerals, made through geologic processes.

Next, in order to help discuss human vs. geologic processes, the teacher showed a 10 minute video from youtube.com called “IsConcreteRock”, which takes students through the entire process from mining limestone to laying a concrete sidewalk, and all the human processes in between (http://www.youtube.com/watch?v=TCvNE5qLEmI). During the video, students completed the “During the Video” worksheet (see Figure 5-3 for a student sample). This was designed to match and highlight the important information in the video, but also to ensure students paid attention. Some students had trouble filling in the blanks quickly enough before the video would move on, so the teacher paused the video at points with text until everyone was done.

Finally, students worked as a class to make a correct “Exploration Table” on the board (or on a clean copy in their notebooks) to help clarify any lingering confusion about why a certain sample was a rock or non-rock.

Elaboration

Once students seemed clear on the rock vs. non-rock idea, the concept was taken a step further with the following guiding question: “Do non-rocks (concrete, brick, glass, asphalt) go through weathering and erosion like real rocks do?” Initially, most students did not think that non-rocks went through weathering or erosion like real rocks do.

Students were given time to explore the school campus to look for evidence of weathering (breaking down of rock) or erosion (movement of rock) in any non-rocks used at the school (e.g., cracks in concrete, rounded or breaking bricks, etc.). The class moved as a whole, with teacher supervision, but individual groups were permitted to explore examples of their choosing within the area.

Students mostly examined forms of cracks in concrete. The teacher encouraged them to think through the order in which the cracks formed and what had happened since the initial crack (e.g., soil settled in crack, plant starting to grow, created side little cracks), as well as where the concrete that had been in the crack had gone.

Once back in the classroom, students were asked first to note their “final answer” on their notes sheet. Then, they were asked to share their findings and to discuss collectively the idea that because concrete, cement, and brick are made of rocks, they go through some weathering and erosion, but not exactly as regular rocks would. After actually observing evidence of weathering and erosion, students could say with certainty they did occur.

Even more importantly, many students had not realized previously that weathering and erosion (the concepts they had been learning in class) were actually occurring in their everyday lives. They expressed shock and excitement that they were able to directly observe these processes, even on non-rocks, and were then excited to go find evidence of the processes in other places. It seems they did not realize these processes happen everywhere; they thought that everything they had been learning happened “somewhere else”. As one student explained, “I knew volcanoes and earthquakes didn’t happen here, so I figured weathering and erosion didn’t either. I thought it all happened like in Hawaii or somewhere.”

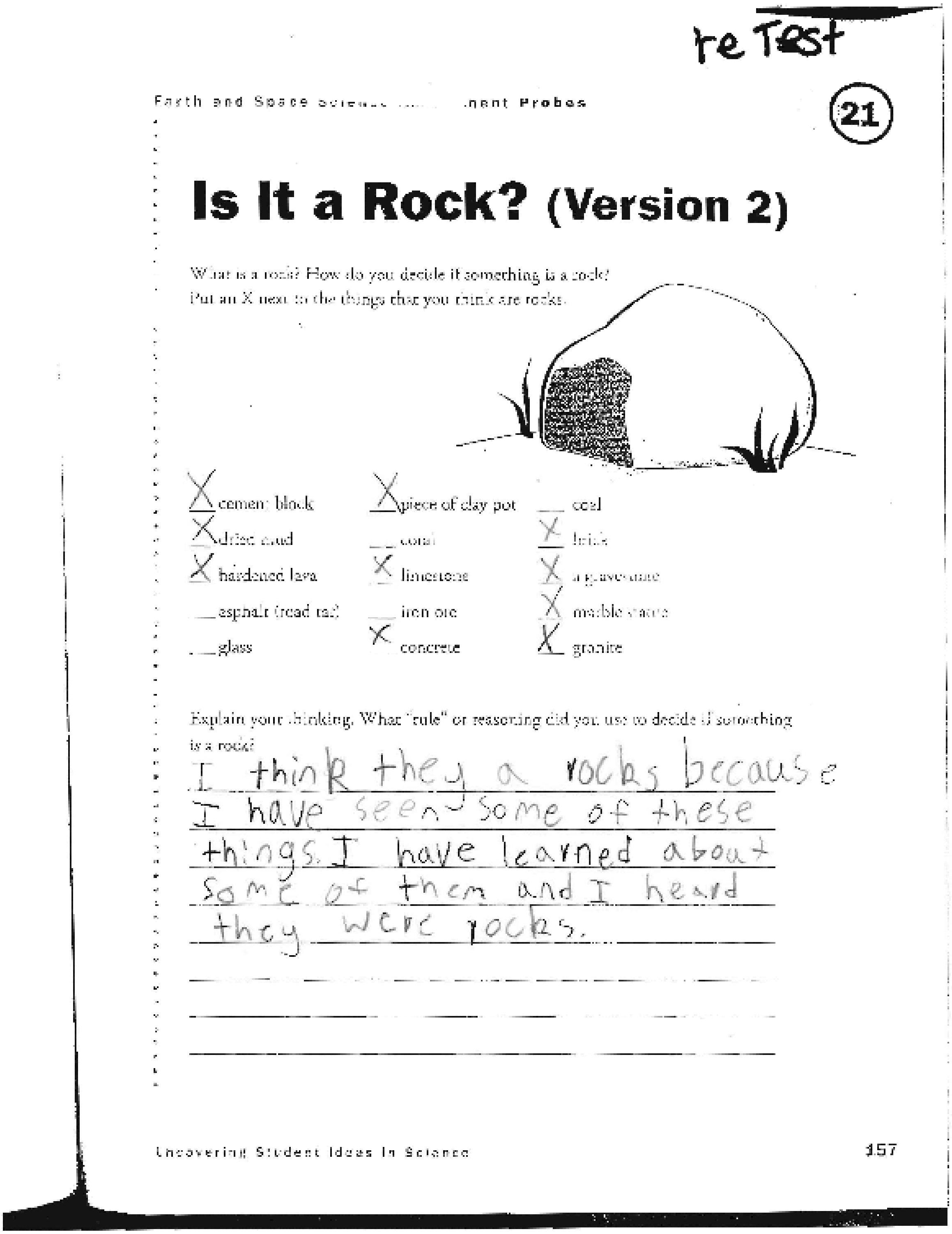
Evaluation

As a final assessment, students were given the “Is It a Rock?” probe again (see Figure 5-4 for the same student’s sample as in Figure 5-1), but this time they had to work individually, and their answers were graded. The teacher looked for evidence of a complete definition of what is and is not a rock, specifically looking for evidence taken from the lesson. Seventy-two percent of students showed a marked increase in comprehension when comparing their pretests with their posttests. Students showed improvement both in selecting the rocks from the list and in their explanations of how they made their decisions.

Final Thoughts

Due to the nature of fourth grade science pacing at the school, this 5E lesson ended up taking three 30-minute classes to complete. The Engage and Explore stages took place on Day One, Explain on Day Two, and Elaborate and Evaluate on Day Three. This resulted in the Explore and Elaborate stages being a little rushed, but taking more than three science periods for this supplementary lesson was not possible. The teacher noted that her students enjoyed the whole lesson, but specifically liked the exploration and elaboration phases a great deal, especially in comparison to some of the more textbook-based activities they had previously done. She noted that while her students usually like science, in this lesson they seemed to “want to figure out what and why” and they “argued their points within the team leading to debate more than they usually do”.

Upon reflection, the teacher was glad she took the three days for this supplementary lesson, and mentioned that student-initiated conversations about this topic continued for the next few weeks. She directly observed a group of students, days after the lesson, pointing out erosion of both rocks and non-rocks while on the playground for recess. Overall, this lesson provided an excellent review of some important geoscience concepts, and it was a great way to extend the students’ geoscience knowledge to include the man-altered materials they see all around them. Additional information relating to the technology used during this lesson and to the National Science Education Standards addressed, are available in Appendices H and I.



re Test

Earth and Space Science Assessment Probes

21

Is It a Rock? (Version 2)

What is a rock? How do you decide if something is a rock?
Put an X next to the things that you think are rocks.

X cement block	X piece of clay pot	__ coal
X dried mud	__ coral	X brick
X hardened lava	X limestone	X a gravestone
__ asphalt (road tar)	__ iron ore	X marble statue
__ glass	X concrete	X granite

Explain your thinking. What "rule" or reasoning did you use to decide if something is a rock?

I think they a rocks because I have seen some of these things. I have learned about some of them and I heard they were rocks.

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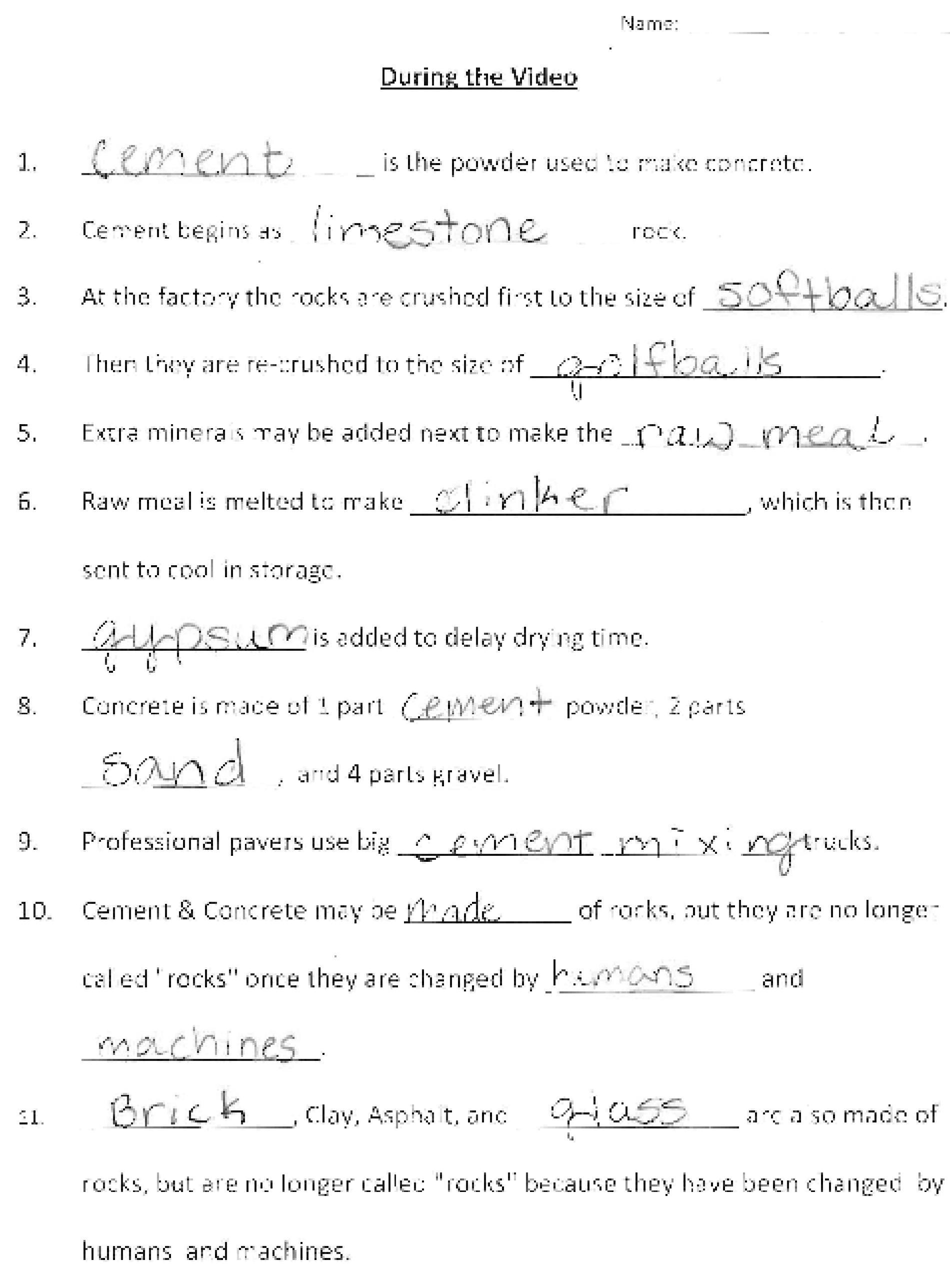
Figure 6-1. "Is it a rock?" formative assessment probe, student sample.

Name: ______________________

Exploration Table

Sample	Observations	Is it a rock? - If yes, what kind? How do you know? - If no, what is it? How do you know?
A	hard, looks like concrete. Gray, bits of white, black, cream.	No. I think it's concrete.
B	dark, rough. Small bits of white and black. Some light pink.	No, I think it's a brick.
C	light brown, dark brown, has bits of white rock, kind-of heavy	Yes. I don't know what kind, though. It's heavy.
D	very light, white, powdery-stuff comes off on your hand when you hold it.	Yes actully. I think it is a "Chalk rock" I don't know why.
E	Looks like a sandwich. Light brown on top, black in the middle and brown on the bottom.	No. I don't think it's a rock, because it look strange and feels strange.
F	Very heavy. Gray, with white, cream, orange, too.	Yes. I think so because it's so heavy.
G	Looks like a brick, dark brown, with small, white bits of rocks in it.	No. I think it's a brick, because of its color.

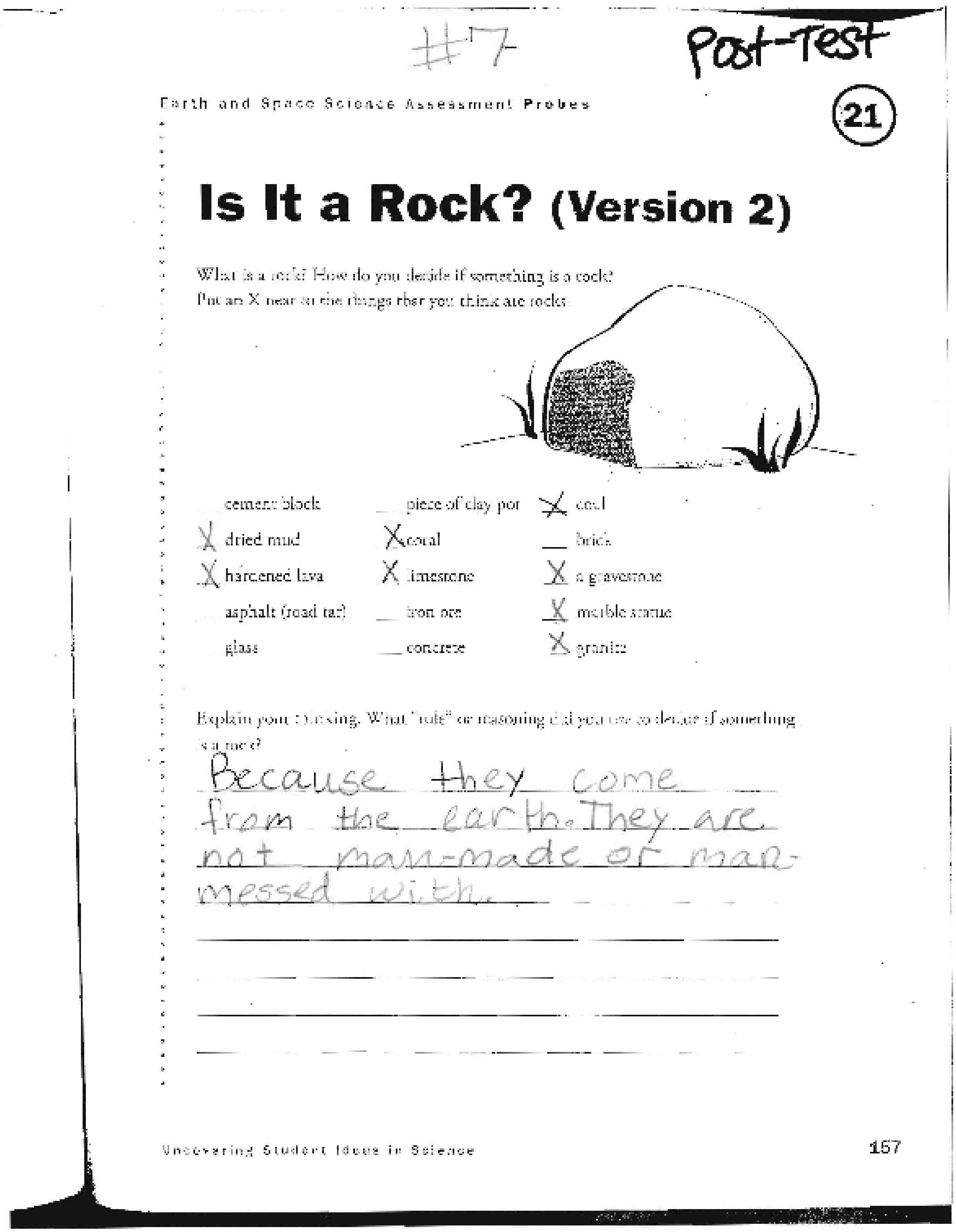
Figure 6-2. “Exploration Table” worksheet, student sample.


Name: ____________

During the Video

1. cement ____ is the powder used to make concrete.
2. Cement begins as limestone rock.
3. At the factory the rocks are crushed first to the size of softballs.
4. Then they are re-crushed to the size of golfballs ____.
5. Extra minerals may be added next to make the raw meal.
6. Raw meal is melted to make clinker ____, which is then sent to cool in storage.
7. gypsum is added to delay drying time.
8. Concrete is made of 1 part cement powder, 2 parts sand, and 4 parts gravel.
9. Professional pavers use big cement mixing trucks.
10. Cement & Concrete may be made ____ of rocks, but they are no longer called "rocks" once they are changed by humans and machines.
11. Brick ____, Clay, Asphalt, and glass ____ are also made of rocks, but are no longer called "rocks" because they have been changed by humans and machines.

Figure 6-3. “During the Video” worksheet, student sample.



\#7 Post-Test

Earth and Space Science Assessment Probes

21

Is It a Rock? (Version 2)

What is a rock? How do you decide if something is a rock?
Put an X next to the things that you think are rocks.

___ cement block	___ piece of clay pot	X coal
X dried mud	X coral	___ brick
X hardened lava	X limestone	X a gravestone
___ asphalt (road tar)	___ iron ore	X marble statue
___ glass	___ concrete	X granite

Explain your thinking. What "rule" or reasoning did you use to decide if something is a rock?

Because they come from the earth. They are not man-made or man-messed with.

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Figure 6-4. "Is It a Rock?" summative assessment probe, same student as in 6-1.

CHAPTER 7
CONCLUSIONS

This study investigated how fifth grade students from an urban elementary school made connections between the formal earth science concepts they learned in class and their everyday lives. It used a constructivist grounded theory framework, which Charmaz (2003, 2005, 2006) identifies as useful in promoting social justice concerns. Additionally, the study operated within a framework of place-based education (Semken & Freeman, 2008; Sobel, 2004), which other researchers have identified as having the potential to promote culturally relevant approaches to teaching and learning (Semken, 2005; Semken & Morgan, 1997).

Six urban fifth graders from Eagle Elementary, a high-poverty urban school of color, participated in this study. While I had invited all of their classmates to participate in the study, I chose these six from those who returned complete consent and assent forms purposefully to represent their peers demographically. Furthermore, these participants demonstrated high levels of interest in participating, and their teacher deemed them likely to be present throughout the entire three-week earth science unit.

I provided each of my research participants with a digital camera to take and use for one week, after they had completed the first week of their earth science unit. During the first of two individual interviews which focused on their thoughts and ideas about earth science, I gave them instructions and guided practice on camera use, as well as directions to take at least 10 different pictures which answered the following question: “Where do you find earth science in your life?”As a guiding reminder, this question was printed and taped to each camera. The use of auto-driven photo elicitation allowed the research participants to photograph where they saw earth science in their lives, and then framed a conversation around the pictures they took and why they took them during the second individual interview.

The first semi-structured interview took place after the research participants had had a full week of classroom instruction in earth science. The interview aimed to probe their ideas about (a) what they remembered learning, (b) what interested them and why, (c) what information they had learned or could use in the future and how they might use this information, and (d) what concepts they identified as being related to their everyday lives, and when they made this connection (i.e., while they were learning or afterward). During the second half of the first interview, participants had guided practice in photographing instances of earth science which they identified on their school grounds. This trial run: (1) acquainted them with use of the camera and provided them opportunities to problem-solve the camera should issues arrive when they independently collected photographs; (2) gave them practice in taking photographs and of journaling their thoughts on the pink sheets in their notebooks; and (3) promoted student agency, reinforcing that they themselves were in control over what photographs they took, and that there were no wrong photographs to take. During the second individual interview, which occurred following the independent photograph collection period, the research participants and I looked through the digital photographs and students discussed the two or three pictures they chose to tell me about as well as those I chose that seemed particularly ripe either for discussion or for furthering a participant’s idea.

Data analysis started with the completion of the first interview, and continually informed all subsequent data collection. The data received initial codes after transcription, after which the collection of interview transcripts constituted the dissertation's data set. It was from this data set that subsequent codes and theory building occurred. Initial coding took place on paper copies of the transcripts. The codes then went into NVivo 8's "free node" function, which served to assist in the generation of focused codes. Afterwards, NVivo's "tree nodes" function assisted helped in sorting data placed in the largest "free nodes" into relevant subcategories. This made establishing links between the ideas and categories constructed from the data set much easier. Clarke's (2003, 2005) concept mapping, or diagramming, provided a "visual representation of categories and their relationships" (Charmaz, 2006, p. 117) during this stage of analysis. This allowed for a more complete fleshing out of the categories and subcategories, as well as the links between them. These diagrammed concept maps established a permeable boundary between focused codes and theoretical codes, which allowed for an analytical moving back-and-forth. This ensured data analysis and theory development proceeded with refinement and clarity.

This dissertation study's major findings, as they relate to the research question "How do urban fifth graders identify, describe, and make connections between earth science as it is taught in school and as it exists in their everyday lives?" involve the role of direct observation, indirect connections, and man-altered materials. I theorize that in order for meaningful, scientifically correct connections to be made between earth science in school and as it exists in students' everyday lives, connections must meet two criteria: a) there must be a way for the concept to connect to their everyday life, and b) the content must be addressed in class (see Appendix G). When content is within a student's lived experience and covered in class, students make connections using direct observation and indirect connections using analogies. If content is taught, but not connected to students' lived experiences (ex. continental vs. oceanic crust), it is lost and no meaningful connections are made. If the content is connected to students' lives, but not taught (ex. concrete, cement), then the connections are attempted by students, but create confusion. This confusion can lead to incorrect scientific assumptions (ex. concrete is igneous rock, because it melts then hardens) when not addressed in the curriculum

Students made the most viable connections to concepts they had (or could) directly observe in their everyday lives. Earth science concepts to which students made direct observation connections included streak, soil layers, and sand, but mostly centered on examples of weathering and erosion. Students created indirect connections between formal earth science content and things they had observed when they could not directly observe the concept or phenomenon they had been taught in class. They made these indirect connections to things they could not directly observe, and this was because the concepts or phenomena they were making indirect connections to did not occur in their everyday lives. Most of the indirect connections students made involved concepts such as earth’s layers, volcanoes, and earthquakes, which they presented as analogies (A is like B). These indirect connections were analogous in terms of appearance, structure, and response.

The final finding of this research identified the significance of non-natural, or man-altered materials (MAMs), in how students made connections to earth science concepts. Every student in this study produced at least one photograph of a MAM - including bricks, concrete, asphalt, and tiles. The students were unable to distinguish between rocks and rocklike materials, and furthermore had no knowledge of how these rocklike materials were made. They expressed incorrect ideas about these MAMs - such that they were “rocks” and were part of the naturally occurring rock cycle. While they correctly recognized that these MAMs go through weathering and erosion processes, they thought they went through the processes exactly as rocks do, which furthered their misconception that MAMs are rocks.

Discussion

This study of urban fifth grade students in a high-poverty school of color sought to answer how these students identify, describe, and make connections between earth science as it is taught in school and as they find it in their everyday lives. Data analysis showed that the students created connections in three ways. First, students made the clearest and most direct connections with earth science concepts taught in class that they could directly observe in their everyday lives. Second, when students were taught an earth science concept that they believed they could not directly observe, they created connections to the concept through use of analogy with things they had directly observed. Finally, students commonly made connections to non-rock materials that were altered by humans for use in society, such as concrete or brick.

Students naturally and easily made connections between earth content taught and examples of that content in their lives outside of school, specifically with examples they could directly observe. This was not surprising as educators (Aylesworth, 1963; McNamara & Fowler, 1975; Mullen, 1962; Piaget, 1964) for many years have noted that more effective learning occurs when that learning is connected to direct experiences. In fact, this concept is a core tenet of constructivist learning as discussed earlier. Previous research by Warren and associates (2001), which shows how poor and minority children used their everyday experiences to provide both context and perspective when learning about science processes, support this dissertation study's findings. Thus, students' everyday ways of knowing science can be successfully used to enhance science learning when facilitated by willing and prepared instructors.

However, one portion of these findings science education researchers have not noted is that, in addition to creating more effective instruction, students preferred direct interaction and observation of earth science concepts. This preference for direct observation was seen clearly in the way two students went out of their way to create situations where they could directly observe the phenomenon they had been taught in class. In addition, all student participants mentioned they especially liked cases where they had known of the example as a part of their lives before earth science instruction and then learned the scientific name (or vocabulary word) for it.

When students were unable to make connections to concepts they had directly observed, they made connections using analogies, or indirect connections. The role of analogies in science education has been thoroughly researched (Clement, 1998; Gentner & Gentner, 1983; Heywood, 2002; Heywood & Parker, 1997; Summers, et al., 1998). Scholars agree that the core purpose of using analogies is to help students understand an abstract phenomenon through connections to a concrete, observable phenomenon (Heywood, 2002). They also note that any explanation of abstract concepts needs to be rooted in students' existing experiences in order for them to accurately interpret the abstract idea (Summers, et al., 1998). As practitioner journals commonly paint analogies as an effective way to engage elementary students in earth science content (Bhattacharyya & Czeck, 2004; Nottis, 1999; Passey, et al., 2006;

Tolley & Richmond, 2003; Winstanley & Francek, 2004), it is important for educators to understand the role of analogies in urban elementary students' indirect connections-making between formal earth science content and their everyday lives is important. However, one should note the possibility that students may deepen or even generate new misconceptions of earth science content through the use of analogies if they do not have the necessary support to make sense of their analogies. This study's findings regarding indirect connections point to this issue directly.

In this study, students obviously wanted to make connections to what they were learning, so much so that they put in the time to develop their own analogies to understand earth science concepts that they were taught, but could not directly experience. Students developed analogies using things they had directly observed that were similar to what they were learning about in terms of appearance, structure, or behavior/response. Of the three types, it seemed the appearance analogies were the least useful for understanding the science concept to which they were trying to connect. This is because while two things may look similar, use of that analogy does not help students understand the relational aspects or causality of the science concept. For example, while soft-serve ice cream coming out of a machine may look like lava coming out of a volcano, there is nothing about understanding the ice cream that helps the student understand the lava. As such, the students' analogies based on structure or response were those that most helped inform their understanding of the science concept. However, as these student-created analogies were not discussed in class, the students were never presented with the need to critically examine the utility or possible limitations of the analogies they created. This teacher supported constant comparison of abstract concept to chosen mental model has been found to be essential to the process where analogies work (Clement, 1998; Heywood & Parker, 1997).

When students were making connections to earth science concepts in their everyday lives, this study found that connections to and confusion over non-natural, or man-altered materials (MAMs), played a significant role in student connection making. Many in the science education community believe that we teach children science in school in order to help them understand their world and make informed decisions about their place in that world (Aikenhead, et al., 2006; Millar, 1996; Turner, 2008). However, that world is not just the naturally-occurring world. The reality of life in our modern society is that students live in a man-altered world of concrete, brick, glass, and plastics. By only teaching naturally occurring geology and earth science processes in our science classes, textbooks, and standards, we are choosing to not teach students the content that would actually connect to their everyday lives. For many years, earth science instruction has been critiqued as failing to provide a "relevant curriculum" (McNamara & Fowler, 1975, p. 413), with suggestions made that when this type of curriculum is used, teachers fail to teach children how the earth science content can be related to their lives outside of school (Glasser, 1969). More recently, Bransford and Donovan (2005) have argued that science instruction that does not "explicitly address students' everyday conceptions" (p. 400) typically fails to help students refine or replace their misconceptions with more scientifically accurate conceptions. Despite these suggestions being presented for over forty years, in this study the same situation was found.

Furthermore, understanding elementary students' misconceptions of earth science content - particularly when working in urban environments - is important. This supports previous research (Dove, 1996, 1998; Ford, 2003; Happs, 1982) that examined or found misconceptions around the role of humans in the natural geologic cycle. These previous studies revealed that students commonly confuse natural and man-made materials, supporting the findings of this study. Happs (1982, as cited in Dove, 1998) found that while research participants easily recognized brick, only one in three realized brick did not occur naturally, just as this study's urban elementary participants did not realize that the concrete and other MAMs they identified in their urban environments did not occur naturally. Additionally, both children and adults were found to apply the term "rock: indiscriminately to rocks, minerals, and man-made materials (Dove, 1996), as did this study's participants.

All of these findings point to the importance of adopting a framework for place-based education in urban environments when teaching earth science content. Previous research (Seiler, et al., 2001, 2003; Tobin, et al., 1999) has found that good urban science education can work to counter a number of the problems typically seen in urban environments including the effects of tracking, teaching to the test, and student resistance to strictly academic learning. This finding is supported by the findings of this study which found that student participants felt use of place-based geoscience took them away from the textbook and test prep, and created a space for them to interact with the earth science concepts without the strict academic context. Furthermore, elaborating on previous place-based education research on Native American and First Nations Canadian populations (Bevier, et al., 1997; Dubiel, 1997; Murray, 1997;

Semken, 2005; Semken & Morgan, 1997; Vierling, et al., 2006), this study suggests that a PBE geoscience curriculum would also help urban, high-poverty elementary learners. However, while this study used a dramatically different population, it found some of the same important qualities in research involving teaching geoscience as that which studies indigenous/native populations (Riggs, 2005). The findings of this research gives support to place-based curricula, specifically use of experiential, outdoor science taking place within the traditional areas where the students were very familiar.

Implications for Science Teacher Education

This study's findings emphasize a need for more place-based education, especially in the teaching of earth science in urban environments. Teachers in these areas need to adopt place-based educational praxes in order to start bridging the gap between earth science as it is taught and as it occurs in their students' everyday lives. Teacher educators should teach inservice and preservice teachers to identify directly observable examples of earth science phenomena on their urban school's grounds and in their neighboring communities. When teaching about weathering and erosion, for example, teachers can have students observe two locations where directed water flow affects the sediment where it is discharged. Students can observe that where rain gutters discharge large amounts of water, large depressions form, but where air conditioning condensers discharge small amounts of condensed water on a day-after-day basis, comparably small depressions form. This simple, cost-free, and immediately local inquiry allows students not only to come to a deeper and more personal understanding of the earth science concepts of weathering and erosion, but also to have the opportunity to discuss this common experience further in whole-class or small group formats.

The indirect connections students made in this study between formal earth science concepts as taught in class and their everyday lives highlight their common use of analogies when attempting to make connections between phenomena they cannot directly observe and their personal experiences. Discussion within inservice professional development and preservice teacher preparation on how to use analogies to deepen students' personal understanding of formal earth science concepts, as well as how to critique these analogies for strengths and weaknesses, may provide classroom teachers with an enlarged instructional skillset applicable to their students' immediate experiences. Teachers can have their students record the personal indirect connections and analogies they make in a science journal, which can serve subsequently as anonymous whole-class prompts for discussion of the related earth science concepts. If a student came to class with the analogy, "Lava moves like soft-serve ice cream coming from an ice cream machine", the classroom teacher could use this analogy anonymously in a whole-class discussion where students would contribute ways that lava is and is not like soft-serve ice cream. This discussion would provide both a review of earth science content related to lava and opportunities to address any potential misconceptions the analogy could generate.

The important role of man-altered materials in how students made connections in this study shows a major disconnect in earth science instruction between what is taught and what is lived. As participants and their teacher did not discuss man-altered materials (MAMs) in class, students assumed they were rocks, developing much confusion on the role these materials play in the rock cycle. Students had trouble additionally with the notion that while humans break and move rocks, neither counts as weathering or erosion. Teachers should supplement their normal earth science curriculum with explorations and discussions to teach that these common man-altered materials are made from rocks, but are no longer called “rocks” because humans and machines have formed them in the place of geologic processes. A teacher could bring in samples of rocks and MAMs and could allow students to observe and discuss which of the samples are “rocks”. The teacher additionally could present a scientifically accurate definition of rock, as well as instructions on how common MAMs are made - such as how materials engineers transform limestone rock into concrete. Without this kind of instruction, teachers leave students to make massive intuitive leaps between naturally occurring processes and human ones.

Implications for Science Education Research

Previous studies using a place-based education (PBE) framework for teaching earth science focus primarily on the experiences of indigenous populations (Aikenhead, 2001; Chinn, 2007; Dubiel, 1997). This study’s findings demonstrate that urban students of color and of poverty likewise may benefit from place-based earth science instruction in making connections between formal earth science concepts and their lived experiences. Further studies in urban schools of color and of poverty may provide additional depth to the tentative findings this research provides, shedding additional light on the effectiveness of using a PBE framework in increasing urban students’ understandings of earth science concepts.

Researchers may also be interested in expanding the scope of this study to include students learning in different educational settings. Exploring the effectiveness of a PBE framework for earth science with urban and suburban middle-to-upper-class students, and with rural students of all socioeconomic status may have a considerable impact on the ways in which students of all backgrounds learn earth science content most effectively.

Researchers finally may want to undertake studies examining whether students' abilities to identify, describe, and make connections between formal earth science concepts and their lived experiences transfers to connections-making in contexts foreign to those students. This consideration has implications which are particularly important regarding high-stakes standardized test items, as existing research (García & Pearson, 1994; Gipps, 1999; Lynch, 2001; Solano-Flores & Nelson-Barber, 2001) demonstrates the effects of cultural bias on students' test performance. As this study focused exclusively on how urban fifth graders make, identify, and describe connections between formal school earth science concepts and their lived experiences, the question of how an earth science education grounded in connections-making affects students' performance on high-stakes tests remains unanswered.

Lessons Learned

In closing this text, I would like to share two of the lessons I learned during this process, specifically around the use of auto-driven photo elicitation with children. First, though the majority of participants found the researcher notebook useful, some had difficulties with it. Additionally, study non-participants involved themselves with research participants' photographing processes to varying degrees. I then share suggestions for future use of ADPE with children stemming from the lessons I learned.

Researcher Notebooks Found Varyingly Useful

Research participants who actively used their research notebook to journal the reasons for which they photographed the things they photographed found the notebook useful. Derek, Courtney, Jamiah, and Butterfly all diligently journaled their thoughts after taking each photograph. However, they each differed on the role of the notebook in the ADPE project. Butterfly found writing in the notebook as the “worst part” of participation in the project. In class, she typically had trouble getting her thoughts down on paper, as she would rather talk than write. This trend continued throughout the project. In contrast, Courtney and Jamiah both liked using the notebooks and recommended their use in any future projects. Courtney felt that writing in her notebook helped her remember why she took each picture, and she referenced it frequently in the second round of interviews. While Jamiah did not look at her notebook during her second interview, she nevertheless explained that because her journaling had made her think about why she took the photographs she took, she had already gone through the thinking process and could recall her reasons. Jamiah also noted that she liked the format of writing in the three guided boxes, as opposed to writing notes on a plain piece of paper. She recounts, “It actually tells you specifically what you need for it, so I kind of looked in the [note]book before I wrote anything to take a picture and I thought of what I was going to write for it”.

The remaining research participants - Man-Man and Fred - comparatively had little success in the use of their notebooks. As noted earlier, Man-Man had used his notebook sparingly. He returned with twenty-three pictures, but had journaled on only four photographs. Additionally, of those four photographs, only one related to Earth Science; the other three were notes on photographs of the sun, clouds, and a plant. Though he did not give a reason as to why he had used his notebook so little, he did say the notebook was useful as it “helps [him] remember” why he took the photographs he took.

Fred had even less success with the notebook, returning with no at-home notes taken. As soon as Fred's second interview began, he immediately expressed concern that he might get into trouble for not completing that part of the task. He also was quick to explain why he had not completed it:

> *Interviewer:* What happened when you brought your camera back home?
>
> *Fred:* My mom took the bag and I took the pictures and then I would show her the pictures, and then I told her that I had to write in a book. And then she saw the pink paper [the guided practice notetaking sheets] which I already wrote on, and then she thought since the pink paper was already wrote on, I didn't need to write anymore. And then she kept it in her room, but she doesn't like me going in her room. I don't know where it was around.

Fred's mom apparently took the researcher notebook for safekeeping as soon as he brought it home, and as such he returned to school having done no at-home journaling. Though the researcher journal had little use to Fred, he fortunately could remember where and why he had taken each of his photographs, and the lack of notes to reference did not heavily influence his responses.

Students reacted differently to the researcher journal and found it useful to varying degrees. While some such as Courtney and Jamiah found it tremendously useful in helping them think about Earth Science concepts and the connections they could make to the local examples they photographed, others such as Butterfly found the exercise tedious. Furthermore, Man-Man and Fred had limited success with the researcher journal, and found it limited in its usefulness.

Involvement of Study Non-Participants

Finally, throughout this auto-driven photo elicitation process, non-research participants involved themselves to varying degrees, for both good and bad regarding the research participants' photographic agency. Fred's mother - who as previously discussed prevented Fred from writing in his researcher journal - was not the only non-study participant to get involved with the research participants' photography processes. All six research participants reported some form of outside human influence from home on their task. This was not completely unexpected, as I had recommended that they did not go out into their communities alone to take their photographs, but rather had someone accompany them for safety reasons. While the three boys chose either to explore on their own or to remain in their yards, the three girls each took someone with them when out taking pictures.

Butterfly, for example, said her thirteen-year-old brother walked around with her, but he did not offer suggestions as to what she should photograph or involve himself further. In contrast, both Courtney and Jamiah reported that the people with whom they explored made suggestions as to what they should photograph. Jamiah walked around with two fifth grade students from a nearby school, and admitted that two of the photographs she had taken - one of a fridge magnet and another of ice melting - were given to her by one of these friends. Similarly, Courtney walked around taking pictures on various days with either her mother, father, or cousin, with her little brothers often accompanying her. Though Courtney stated that, while having asked her mother for ideas on what to photograph, she stated that the ones she had taken and journaled about were hers and hers alone. However, her brothers had at some juncture accessed her camera while she was not present and had taken numerous out-of-focus and poorly lit pictures of themselves. As photographs taken by or suggested by others are inconsistent with the auto-driven photo elicitation method, I excluded them from the data set.

Fred also had trouble with others using his camera and his camera card. First, as we went through his photographs, Fred noted that one of the pictures on his card was taken by his five-year-old brother. He had allowed his younger brother to take one picture so the younger brother could feel as though he was part of the ADPE project. Additionally, his aunt and mother had both placed photographs they had either taken or found on his camera card - his aunt, an aerial photograph of a sinkhole, and his mother, a satellite image of the state of Florida. I excluded these photographs likewise from the data set and as discussion prompts.

Much as Jamiah and Courtney had others make suggestions as to what photographs she should take, so Man-Man's mother made suggestions to him. Man-Man's mother's suggestions were mostly of plants and flowers, which may explain in part why Man-Man seemed to have difficulty distinguishing between Life Science and Earth Science. After going through Man-Man's photographs, I divided the photographs resulting from his own ideas from those his mother had suggested, and excluded the latter.

Overall, only Butterfly and Derek appeared to not have issues arising from non-study participants taking part in the photography process. Though Butterfly's older brother escorted her for safety purposes, she reported he had not influenced her photographic decision-making process. Likewise, while Derek reported that his mother interrupted his photography by making him clean his room, which caused him to forget to journal a few of his photographs immediately, he returned to the photographing and journaling as soon as he had finished cleaning his room.

Suggestions for Future ADPE Research

One of the most valuable lessons learned in this study was the importance of using the student researcher notebooks to allow students to keep notes on what they photographed, where they took their photographs, and why they chose to photograph a particular example. Jamiah and Courtney explained that the researcher notebooks helped them remember why they had photographed the examples of earth science content they had photographed. This process thus seems to have facilitated metacognition and memory. I believe the use of a similar student researcher notebook, with guiding prompts and questions, is highly advisable for other researchers seeking to use auto-driven photo elicitation with children or students.

In reporting on their research using photo elicitation with children, John Barker and Susie Weller (2003) explain how when working with four- to nine-year-olds, they found over the course of interviews that parents rather than the children themselves had actually taken the photographs. However, in working with thirteen- and fourteen-year-olds, they found their respondents' photographs were neither influenced nor taken by their parents. Having read about the potential for parent interference, in this study I glued a note into the research participants' researcher notebooks, both for their parents' and students' own understanding. This note explained that research participants would use a camera over the course of weeklong period, and it included directions regarding what I was asking the participants to do during the period of photo collection. It was my hope that by informing parents of the parameters of their children's task, they would understand not only the importance that the task be completed but that it was completed only by the research participants. However, in retrospect, I should have sent this note home directly to parents in a sealed envelope, and should not have assumed that students would have shown their parents the directions in their notebook.

This assumption led to a considerable amount of non-study participant involvement, leading to some less than desirable results. Gemma Moss (2001) found in a visual study analyzing children’s photographs of literacy in their homes that parents and family members were involved in the photography process. In that study, students asked parents to pose with reading materials or deliberately to stay out of the photographs, but also asked parents to take staged photographs of student participants reading in the home. Comparatively, in this study, family members and friends, both older and younger than the research participants, played roles including accompanying students while they took photographs, discussing and suggesting what photographs to take, taking photographs on their own without the research participants’ permission, and interfering with task completion. In future ADPE research with children, I suggest a letter be sent home along with the camera to the parents explicitly explaining what the students have been asked to do, and what they should and should not do to help their child with the project.

APPENDIX A
IRB PROTOCOL

1. Title of Project: Making Connections Between Formal School Earth Science and Lived Experiences: An Investigation of Urban Fifth Graders

2. Principal Investigator: Katie Lynn Milton Brkich, Doctoral Candidate and Alumnus Fellow, University of Florida, School of Teaching and Learning, [redacted]

3. Project Supervisor: Rose Pringle, Associate Professor of Science Education, University of Florida, School of Teaching and Learning, [redacted]

4. Dates of Proposed Research: August 2010 - August 2011

5. Sources of Funding: None

6. Scientific Purposes of the Investigation: The purposes of this research are threefold: (1) to explore urban fifth graders' academic understanding of the earth science concepts they are presented in their classrooms; (2) to explore the connections they make between this academic content and the world beyond the classroom; and (3) to identify the opportunities these students have for generating scientific misconceptions regarding the academic content they are taught, as identified by the connections they make.

7. Describe the Research Methodology in Non-Technical Language: The principal investigator will spend two to three weeks in a fifth grade classroom, the period of which will coincide with the school board's earth science instructional timeframe. During this period, the principal investigator will perform field observations and collect general field notes regarding the earth science instruction.

During the second week, the principal investigator will conduct semi-structured individual interviews with the research participants, which will each last from 60-75 minutes and will be digitally videotaped and audio recorded. These interviews will focus on the research participants' recollections of their earth science learning from the first week; the things which interested them about this learning; what they considered useful to their lives, and in what ways this learning could be useful; and the concepts they related to their lives beyond the classroom (see *Interview Protocol A*). Additionally, during this same interview, the principal investigator will provide the research participants with a digital camera to take photographs during a walking tour of the school of instances the research participants identify as demonstrating the earth science content they learned the previous week (see *Camera Instructions*). This interview will close out with the research participants sharing their digital photographs with the principal investigator and discussing the reasons for which they took those photographs and the earth science connections they identified in each of the photographs.

Following this initial interview, the principal investigator will provide the research participants a period of one week to take additional photographs, outside the school, identifying the earth science content they learned. The research participants will keep notes in a notebook provided by the principal investigator the reasons for which they took the photographs and the earth science connections they identified at the time they took the photographs. Additionally, the research participants will mark on their own copies of the drawn maps of their areas of activity where they took their photographs and where they explored in looking to take their photographs.

After the one-week period has elapsed, the principal investigator will conduct a second series of semi-structured individual interviews with the research participants, which will each last approximately 60 minutes and will be digitally videotaped and audio recorded. These interviews will focus on the digital photographs the research participants collected in the previous week, the reasons for which they took these pictures, the connections to the earth science content they identified in the pictures, and the changes they made to their drawn maps of their areas of activity.

Data sources will be restricted to observational field notes, the digital video and audio recordings of the open group conversation and individual interviews, research participant-taken digital photographs and photograph notebooks, and the drawn maps of research participants' areas of activity.

As issues emerge in the process of collecting data, the researcher will follow up with further semi-structured digitally audio recorded interviews which relate to the purpose of this scientific investigation.

8. Describe Potential Benefits: This investigation will shed light on how urban fifth graders make sense of the earth science content presented to them at school and how they apply this earth science content to their lives beyond the school. Direct benefits to the research participants include a deepening of their understanding of taught earth science content. Additionally, indirect benefits include a greater understanding of how urban fifth graders apply learned earth science content, which may inform the science scope and sequence of elementary teacher education programs to provide for more effective urban elementary schoolteachers.

9. Describe Potential Risks: There are no perceived risks for participation in this study. No persons other than the principal investigator and project supervisor will have access to the data collected. All research participants will be assured that any data collected will not be used in any evaluation of their school performance, written or otherwise, for the purposes of assigning grades. The principal investigator will use fictitious names in any written reports and omit specific references to the specific year, semester, or period during which the data were collected. Research participants will not be held financially accountable for any loss or damages done to the digital cameras the principal investigator will provide as a part of the study. Additionally, the principal investigator will conduct the collection activities during the times permitted by the classroom teacher, thus ensuring the students' regular classroom activities are minimally disrupted.

10. Following approval from the University of Florida Institutional Review Board, the primary investigator will secure official permission from the school district in which she plans to recruit her participants. Once the primary investigator has secured this official permission from the school district, she will contact her associate who is the elementary science coordinator for the school district. This associate will establish contact with an urban fifth grade classroom teacher who will be willing to allow the primary investigator the opportunity to observe her classroom and recruit research participants.

Once in this classroom, the primary investigator will distribute to all students consent packages, which will two copies of the informed consent letter (see *Informed Consent Letter*), and a copy of the assent letter (see *Assent Letter*). Those parents who wish to allow their children the opportunity to participate in the study will be encouraged to return a signed copy of the informed consent letter to their classroom teacher, who will then turn these letters over to the primary investigator privately.

11. Describe the Consent Process: Those students whose parents return a signed copy of the informed consent letter (see *Informed Consent Letter*) will be placed in an initial pool of potential research participants. From this pool, the primary investigator will privately and individually offer the opportunity to the potential research participants to assent (see *Assent Letter*). Only those whose parents consented to their children's participation will be offered the opportunity to assent. During this individual and private meeting, the primary investigator will read aloud the assent letter to the potential research participant, noting that even though their parents have consented to their participation that their participation is not required if they do not want to participate; that they will be assigned pseudonyms throughout the research project; that during interviews, potential research participants may refuse to answer any question for any reason; that participant confidentiality will be assured by the fullest extent permissible by law; and that participants may remove their participatory assent and participants' parents may remove their consent at any time for any reason without let, hindrance, or qualification and without fear of consequence or reprisal.

Those potential research participants who are willing to participate must both orally and in writing assent to their participation. Only those who assent, whose parents have previously consented, will constitute the study's participants.

____

Principal Investigator Signature Date

____

Project Supervisor Signature Date

I approve submission of this protocol to the University of Florida Institutional Review Board.

Department Chair Signature Date

APPENDIX B
INFORMED CONSENT LETTER

Dear parent/guardian,

I am asking you to consent to your child's participation in my dissertation study, which is a study of urban fifth graders' experiences with earth science instruction and the connections they make between this instruction and their lives outside of school. I am a Doctoral Candidate, Alumnus Fellow, and instructor for the School of Teaching and Learning, which is housed within the University of Florida's College of Education. Rose Pringle, my committee chair and doctoral committee supervisor, is an Associate Professor of Science Education within the School of Teaching and Learning.

If you consent to your child's participation in this study, your child will be offered the opportunity to participate. If your child agrees to participate, s/he will be placed in a pool of potential participants. If selected to participate, s/he will participate in a group conversation with her/his other classmate participants in which they will draw maps of their areas of activity.

Next, your child will participate in two individual interviews. The first interview will last between sixty and seventy-five minutes, and will focus on your child's earth science learning recollections and connection-making. As part of this first interview, I will provide your child with an inexpensive digital camera, which s/he will use to take pictures of earth science content around her/his school while on a walking tour with me. We will then discuss the pictures your child has taken.

Following this, I will allow your child to retain the digital camera for a period of one week, during which s/he will take additional pictures of where s/he identifies earth science content outside of school, take notes in a notebook I will provide about where s/he took the pictures and the earth science content s/he identified, and make additions to her/his drawn map of her/his areas of activity. After this period has ended, your child will participate in a second interview lasting approximately sixty minutes in which we will discuss her/his pictures, notebook, and changes s/he made to her/his map.

I will digitally record the group conversations and individual interviews using visual and audio recording devices.

I will analyze your child's responses, photographs, and maps to develop some general characteristics and conclusions about this information. There is no risk to you or your child; the data I collect will in no way affect her/his academic evaluation, written or otherwise, for the purposes of assigning school grades; your child will not be held financially accountable for any loss or damage to the camera I will provide her/him; these activities will only take place during times approved of by your child's classroom teacher, so as not to disrupt your child's education. I will protect your child's confidentiality to the fullest extent permissible by law, and will breach this confidentiality only when required by law (if information is disclosed that indicates child abuse/neglect, or that your child plans to harm herself/himself or others). I will use fictitious names in any written reports, which will omit references to the specific year, semester, or other period in which your child participated.

Your child may choose not to participate in this study even if you give your consent; I will offer her/him this opportunity before I begin the group conversation. Your child may not participate in this study if you do not consent to her/his participation.

Your child will receive up to $10 in gift certificates for her/his participation in this study. Direct benefits to your child include a deeper understanding of earth science content in preparation for the state's standardized science examination. You are free to withdraw your consent for your child to participate in this study at any time without prejudice. Also, your child is free to withdraw her/his assent to participate in this study at any time without prejudice. If you wish, I will share the results of this study upon its completion.

By signing this letter, you give me permission to seek your child's assent to participate in this study. If your child assents, you give me permission to collect the data mentioned above and to report the results in published monographs and reports (e.g., in journal articles, book chapters, etc., and at local, state, and national conferences). By signing, you also waive your rights to ownership of the photos and drawings created by your child and give me permission to use them, with identifying features removed, in my work. I will analyze all collected data, and both data collection and analysis will be overseen and verified by my committee chair and doctoral supervisor.

Please sign and seal one of the copies of this letter in the envelope provided, and have your child return the envelope to her/his classroom teacher. A second copy of the letter is for your records. If you have any questions regarding the study or the procedures for data collection, please contact me or my doctoral committee chair Rose Pringle. If you have any questions about the rights of research participants, you can contact the University of Florida's Institutional Review Board Office at PO Box 112250, University of Florida, Gainesville, FL 32611-2250.

Sincerely,

Katie Lynn Brkich, MEd
Doctoral Candidate, Science Education
School of Teaching and Learning
College of Education, University of Florida
[redacted]

I have read the procedures described in this letter. I have received a copy of this description, and consent voluntarily to my child's participation in this research study.

Parent's Name (print)	Child's Name (print)
Parent's Signature	Date

APPENDIX C
ASSENT LETTER

Hello ______________________________ [child's name],

My name is Katie Lynn Brkich and I am a student at the University of Florida. I am trying to learn about how students think and learn about earth science in fifth grade and about where they see earth science in their lives outside of school. I will be working with several students at ______________________________ [name of school]. If you decide to participate and are selected, I will ask you to do a series of activities, including taking part in a small group conversation, drawing a map of your areas of activity, taking photographs both around school and outside of school where you see earth science, and answering some questions about your experiences with earth science learning. We will spend about a total of three hours during school time doing these activities together, and you will have up to a week outside of school time to take additional pictures with a digital camera I will lend you. There are no known risks to participation, and most students actually enjoy taking the photographs. You do not have to be in this study if you don't want to, and you can quit at any time. Other than myself and my supervisor, Dr. Rose Pringle, no one will know your answers, including your teachers or your classmates. If you don't want to answer a question you won't have to, and if you ask, your answers won't be used in the study. I also want you to know that whatever you decide, this will not affect your grades in class. Your parent/guardian said it would be ok for you to participate. Would you be willing to participate in this study?

If so, please write your name on the line below.

Sincerely,

Katie Lynn Brkich, MEd
Doctoral Candidate, Science Education
School of Teaching and Learning
College of Education, University of Florida
[redacted]

I want to participate in this study, and I know that my parent/guardian has said it is ok for me to participate.

______________________________ ______________________________
Student's Name (print) Date

APPENDIX D
CAMERA INSTRUCTIONS

In one week, we are going to meet again to talk more about this topic. During the week, I would like you to take this digital camera home with you and then take pictures of earth science wherever you see it, just like we did as we walked around the school together today. You will be allowed to keep and use the camera for the whole week, so I want you to take at least 10 different pictures for us to look at together. You can take pictures of whatever you want as long as it helps answer this question (which will be taped to the camera): Where do you find earth science in your life? I am going to give you this little notebook to use as you take the pictures, when you take a picture write down what you are thinking and why you decided to take that picture. Additionally, I want you to take home a copy of your map to use. I would like for you to do two things to the map: (1) shade in with a colored pencil the areas where you went looking to take pictures, and (2) put a star or asterisk in the spots where you took the pictures. When we meet again in one week, please be sure to bring the camera, your notebook, and the map back with you. I will give you a reminder slip in class the day before we meet again. What questions do you have for me?

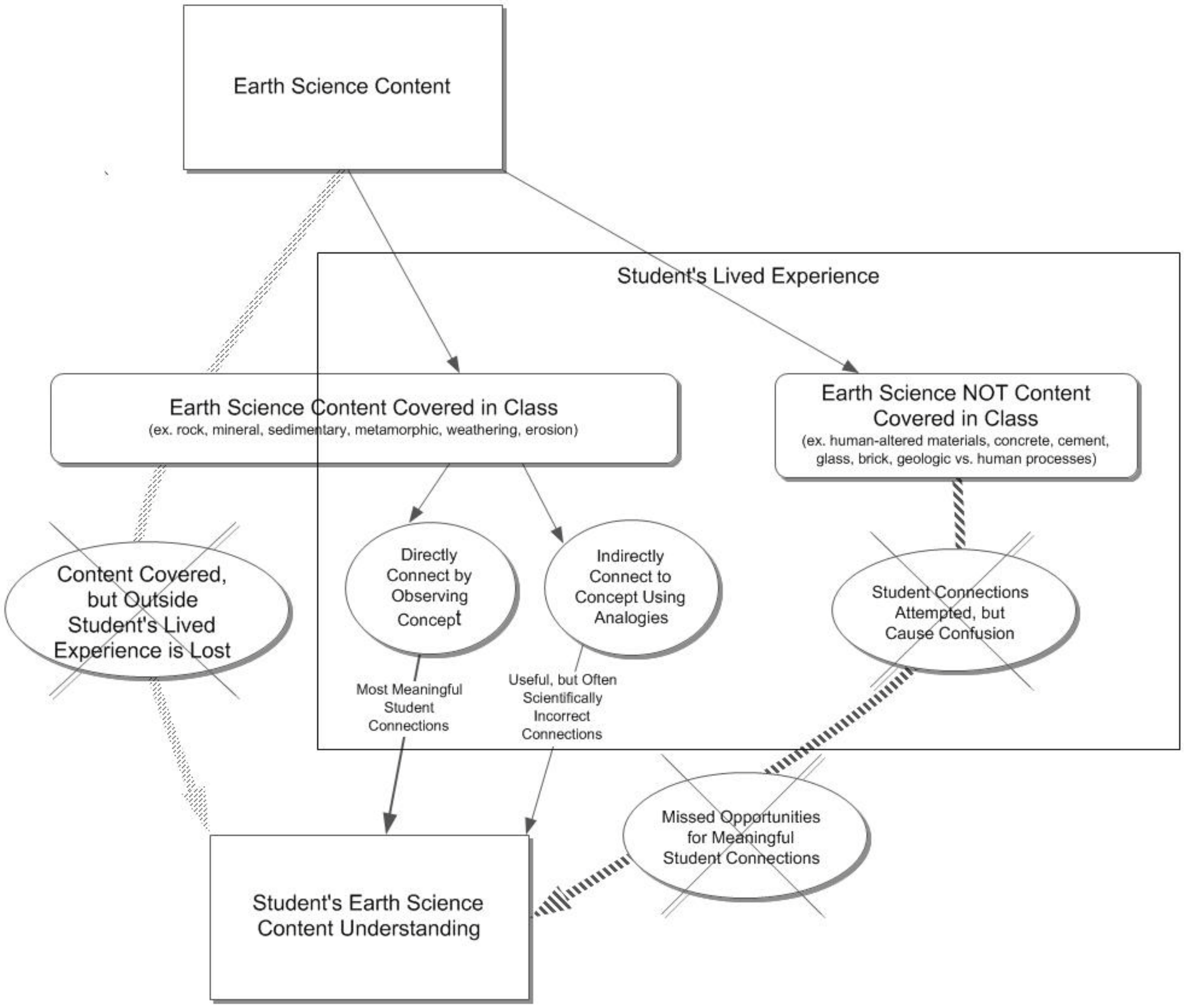
APPENDIX E
FIRST INTERVIEW PROTOCOL

- What is your favorite thing in science?
- What do you know about science?
- Why do we study science?
- What have we been talking about in science lately?
- What is something that interests you in earth science?
- What is something that you went out and told someone about from earth science?
- What is something in earth science that you could easily relate to something else?
- What is something in earth science that you related to your life?
- What is something from earth science that you think you have already used somehow?
- What is something from earth science that you think you might use in the future?
- (After student has told me about some of the things on the board, choose some other topics that haven't been mentioned and probe those) What about _____ (ex. Dirt)? You said you learned about dirt this year, was anything about dirt interesting/important to you? Did anything you learned about dirt seem to relate to your life? Why?

APPENDIX F
SECOND INTERVIEW PROTOCOL

- Let's start by looking through all the pictures you took. If you see one you want to tell me about, you can stop me.
    - Tell me about this picture.
    - What do you see in this picture?
    - Why did you choose to take it?
- Now (*with all the pictures in thumbnail form on the screen for student and I to see*) I would like you to pick two or three pictures that you think best show where you found earth science to photograph.
    - For each picture:
        - Tell me about this picture.
        - What do you see in this picture?
        - Why did you choose to take it?

APPENDIX G
THEORY MODEL



APPENDIX H
TECHNOLOGY NOTE

While the teacher in this lesson was able to directly access the instructional video from YouTube, recommended practice for teachers using internet videos is to download these videos so as not to be dependent on an active internet link during instruction. Download Helper (www.downloadhelper.com) is a free and useful tool. Teachers should be aware of their legal rights and responsibilities within the constraints of Fair Use Copyright, which allows teachers the use of YouTube videos for instructional purposes.

APPENDIX I
CONNECTING TO THE STANDARDS

This article relates to the following *National Science Education Standards* (National Research Council, 1996):

Grades K-4

Standard D: Earth & Space Science

- Properties of earth materials

Standard E: Science and Technology

- Abilities to distinguish between natural objects and objects made by humans

Standard F: Science in Personal & Social Perspectives

- Types of resources

Teaching Standards

Standard A

- **Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.**

Standard B

- Orchestrate discourse among students about scientific ideas.

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BIOGRAPHICAL SKETCH

Katie Lynn Milton Brkich was born in 1981 in Florida, and is the only child of John and Carol Milton. She graduated from the University of Florida in August 2011 with a PhD in Curriculum and Instruction. Her major area of concentration is elementary science education.

Katie spent her formative years in Lake Como, Florida. She graduated from Crescent City Junior/Senior High School in May 1999. She subsequently pursued her bachelor's degree in environmental science and policy from the University of South Florida, and graduated with honors in December 2002. She began pursuing her professional studies in education at the University of Florida in January 2003, and graduated with a master's degree in elementary education from the Site-based Implementation of Teacher Education program in May 2004. After teaching for three years in Florida - one at South Ocala Elementary School, and two at MK Rawlings Elementary School in Gainesville - she returned to the University of Florida in 2007.

Katie is a peer-reviewed published author in the field of science education, having several practitioner-oriented articles published in *Science and Children* and an upcoming researcher-oriented article in press with *School Science and Mathematics*. She has presented her scholarship at numerous local, state, national, and international conferences, including the National Science Teachers Association, the National Association of Research in Science Teaching, and the American Educational Research Association.

Katie married Christopher Andrew Brkich in December 2009. They have two beagles, named Annabelle and Effie. In June 2011, they moved to Statesboro, Georgia, to accept positions in Georgia Southern University's College of Education.