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Exploring the Potential of Using Explicit Reflective Instruction through Contextualized and Decontextualized Approaches to Teach First-Grade African American Girls the Practices of Science

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Abstract

Contemporary science education policy documents call for curriculum and pedagogy that lead to students' active engagement, over multiple years of school, in scientific practices. This participatory action research study answered the question, "How can we successfully put twenty-three first-grade African American girls attending a gender school in an impoverished school district on the path to learning the practices of scientists". The Young Children's Views of Science (YCVOS) (Lederman, 2009) was used to interview these first-graders pre-, mid- and post-instruction during an instructional unit designed in response to many of the pedagogical strategies research has demonstrated to be effective in other contexts; explicit reflective instruction utilizing contextualized and decontextualized activities. Classroom observations, copies of student work and planning documents were also collected and analyzed. The cumulative findings indicated that the decontextualized aspects of our science initiative had positive impacts on the girls' understandings of observation and inference while the contextualized aspects of instruction supported an increase in their understandings of empirical evidence. The contextualized aspect of instruction appeared to hinder our efforts in regards to observation and inference. The results extend current understandings of the potential of using these approaches to teach first-grade African American girls the practices of science by supporting some of the aspects of these approaches and raising questions in regard to others.

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Introduction

Contemporary science education policy documents call for curriculum and pedagogy that lead to students' active engagement, over multiple years of school, in scientific practices (National Research Council (NRC), 2012). Such experiences shape an individual's understanding of how scientific knowledge is developed, how it is used, and ultimately places her/him in the community of users and producers of scientific knowledge. For K-12 education, the recommendation is that these practices are formally introduced early and continually built on as the students construct increasingly sophisticated understandings over the years (Forawi, 2007; NRC, 2012). In the elementary schools in our university/school partnerships, we sought to begin this path to understanding the scientific practices by formally introducing the practices of observation, inference and evidence. Empirical evidence refers to qualitative and quantitative data used to develop and confirm scientific ideas. These empirical data are derived from observation using the five senses and scientific inferences which are logical interpretations based on these observations and prior knowledge. Science education research has shown that young children can attain informed formal understandings of these specific practices, and has provided teachers with specific pedagogical strategies that enhance that attainment (e.g., Akerson & Volrich, 2006; Khishfe & Abd-El-Khalick, 2002; Metz, 2004). Overall, this prior research revealed that many elementary students hold naïve conceptions about these practices of science, demonstrated that these conceptions can be improved as a result of appropriate instruction, and provided insights into the pedagogical strategies that are included in such instruction. However, although some recent efforts have sought to address equity issues in regards to these understandings and elementary children from diverse populations (e.g., Akerson, Weiland, Nargund-Joshi, & Pongsanon, 2013; Walls, 2012), the research base currently provides a very limited understanding in this regard. Such a limitation prohibits an inclusive approach to teaching and learning by fostering curricula, content, and pedagogical strategies that are developed from the understandings and for the needs of a narrowly defined segment of the population.

Literature Review

Elementary Children's Understandings of the Scientific Practices

Science is a critical component of a student's educational experience. *The National Framework for K-12 Science Education* (NRC, 2012) emphasizes the need to address the practices, core ideas and crosscutting concepts of science in children's K-12 educational experience. The term 'practices' is used throughout the documents to refer to the activities of scientists that are done repeatedly with increasing levels of proficiency (e.g., Bybee, 2011; Michaels, Shouse, & Schweingruber, 2008). By repeatedly engaging in the practices of science, students "form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview" (National Research Council, 2012, pg. 42). The *Framework for K-12 Science Education* categorizes the practices into eight groupings. Cutting across these groupings, and laying the foundation for engaging in all of the practices, are the skills and understandings associated with observation, inference, and evidence.

Over the course of twenty years, researchers have explored elementary students' understandings of the various practices of scientists. This research base provides us with an understanding of many children's initial understandings regarding these practices, as well as how they develop within formal elementary education. For example, prior to formal instruction elementary students showed an inadequate view of scientific evidence as well as the distinction between observation and inference by believing scientists know things because they can "look them up" (Akerson & Donnelly, 2010). This research base further provides understandings of the impact of early formal instruction on these views. First and second grade students are able to improve their understandings of the empirical nature of science and the distinction between observation and inference, indicating that they are not too young to conceptualize informed levels of these ideas (Akerson & Donnelly, 2010). Indeed, children develop understandings through their experiences in the world, and appropriate science teaching that uses their abilities to reason, conceptions of cause and effect, abilities to understand modeling, abilities to consider ideas and beliefs, and their eagerness to learn, has much potential to help them improve their understandings of science concepts (Michaels, Shouse, & Schweingruber, 2008).

Research has shown that while these practices are implicitly targeted in everyday science instruction, students often miss them. It is important for a teacher to explicitly draw out and direct students' attention to the ideas and help them challenge any misconceptions (Clough, 2006). Meichtry's research (1992) revealed that many middle school students' understandings of empirical evidence is not adequate, and participating in an inquiry program that does not explicitly emphasize such understandings may actually result in a decrease in their understandings of the developmental and testable science. Khishfe and Abd-El-Khalick (2002) explored this notion in elementary schools, finding that the students in an explicit inquiry group improved in their understanding of the distinction between observation and inference. Clearly, explicit approaches for teaching observation, inference and evidence are warranted in the literature. Furthermore, Clough (2006) argues effective instruction on these aspects of the nature of science scaffolds back and forth along a continuum from decontextualized to highly contextualized. He theorizes that such instruction should always be explicitly part of science instruction, but that it can range on a continuum from decontextualized (not connected to science content) to highly contextualized (embedded in science content with the teacher helping students draw connections to the aspects of the nature of science). A teacher who includes instruction on observation, inference and empirical evidence across this continuum should have much success in helping students develop better conceptions of these scientific practices.

Looking at the outcomes in the above studies, Akerson and Donnelly (2010) explored the kinds of understandings eighteen elementary-age children, grades K-2, gained from science instruction that was designed to scaffold their understandings through explicit reflective decontextualized and contextualized instruction. In that study, conducted in a six-week informal science education program in a large midwestern university, the instructors were able to focus specifically on the aspects of the nature of science. Their instructional unit included (1) introducing the aspects of the nature of science through decontextualized activities, (2) embedding these aspects into science content through contextualized activities, (3) using children's literature, (4) debriefings and embedded assessments, (5) guided and student-designed inquiries. The focus of these strategies was on empirical, creative, tentative but robust, and subjective nature of science, as well as to help the students distinguish between observation and inference. The findings from this study further supported the work of Metz (2004) in that the elementary students were able to attain improved understandings as a result of explicit instruction. The first graders in this earlier study developed adequate views of all aspects of the nature of science; although none developed informed understandings. Nearly all the students developed an adequate understanding of the creative aspects of science. All but two students attained an adequate understanding of the difference between observation and inference. As a result of this work, the researchers recommend instruction that spans the decontextualized/contextualized (Clough, 2006) continuum and instruction that is embedded within the disciplinary core ideas that is taught each day through explicit reflective methods.

The Imperative to Include Research on Elementary African American Girls

Although research in science education has done much to increase the understanding of elementary children's science education experiences, it has not gone far enough. Only recently have inquiries in this area addressed gender, race and SES. This emerging research has shown that some of the claims for elementary children in science are not true for young children of all situations. From this research, the science education community understands that African American girls' from low SES communities are uniquely affected by school experiences. For example, Rollock (2007) demonstrated that silencing is critical to understanding the often-ignored Black females, as much of the focus on achievement gaps tend to highlight only their male counterparts. This silencing may explain why African American girls often adopt negative academic strategies such as underperforming and selecting lower level courses to avoid negative interactions (Fordham, 1993). However, there is also research that questions whether these findings are a reflection of African American girls or the educational settings of which they are a part. Chavous, Rivas-Drake, Smalls, Griffin, & Cogburn (2008) showed that girls from low SES backgrounds report higher academic importance values and that girls with higher SES backgrounds were more vulnerable to negative experiences; questioning whether gendered relationships are influenced by school experience. These emerging findings enhance the understanding of factors that can negatively influence efforts to reduce the achievement gap in minority, urban, and gendered groups–an understanding that cautioned us to question any preconceived notions we may have held about a typical understanding of these girls.

The challenges faced in science education are deeply rooted in the ongoing struggle for racial, class, and gender equity. First, significant differences in class, ethnicity, and gender have made the distribution of resources a major contributing factor to differential success among groups of learners (Barton, 2007). Second, a part of this struggle is tied to the rich diversity of students and creates a challenge for educators to generate new ways of understanding, valuing, and succeeding in school-based practices. Non-mainstream students find science to be culturally incongruent with their lives outside of school. Studies focusing on congruence pay close attention to the funds of knowledge that students bring to the classroom. Funds of knowledge include the knowledge students' gain from their culture, communities, families, and linguistic backgrounds they bring with them to school (Gonzalez, Moll, & Amanti, 2005). Additionally, through the introduction of scientific literacy into educational research, the focus of urban education research has shifted to how learning science occurs in these areas. By doing this, the research has stepped away from a particular outcome measure in order to understand how learning is controlled by this context. Third, straying from a deficit model to one of empowering non-mainstream students has led some researchers to focus on the fact that when opportunities are provided, diverse students tend to excel in science (Tal, Krajcik, & Blumenfeld, 2006). Realizing such differences leads to an imperative to include literature on diverse students in the contemporary research base.

Theoretical Underpinning Used to Include Research on Elementary African American Girls

The research on young children's learning experiences involving the scientific processes, noted above, has a conceptual change theoretical underpinning. This theoretical approach emphasizes that learners come to the science classroom with preconceptions about how the world works. Students approach new science learning experiences with these previously acquired understandings which in turn influence the learning process (Donovan & Bransford, 2005); thus, it is imperative to recognize these preconceptions as well as the experiences that fostered them (Driver, Guesne, & Tiberghien 1985). Driver, et al., (1985) proposed a possible model related to cognate science for the ideas that affect the learning process. This model described the interaction between children's ideas and how these ideas change with teaching. An underlying assumption of this model is that a child's stored knowledge influences and is influenced by everything they say and do. The ways a new piece of information gets assimilated depends on both the nature of information and the learner's schemes. By looking at students' schemes in this manner, teachers are able to address the personal, contradictory, and stable ideas that affect the learning process. Restructuring students' naïve or inaccurate ideas may be accomplished by providing them with a wide range of experiences with the scientific world, as well as challenging their current scientific conceptions.

Though the existing research base on teaching elementary students about the practices of science, guided by the conceptual change approach, may have included marginalized students in the data set, most of that research does not describe the population in terms of culture or gender in relation to nature of science conceptions (Walls, 2012). Walls and Bryan (2009) reported that gender was reported 76% of the time and race was only reported 24% of the time. In addition, out of a total of 981 participants identified by race, 883 (89%) were White; 21 (2%) were Latino/a; 9 (1%) were Asian; and 3 (<1%) were African American. Thus, the science education community cannot know whether the pedagogical strategies identified in the literature meets the needs of all, or simply the majority of, students.

Our Stance

The conceptual change tradition guided our inquiry as we explored the girls' initial conceptions of observation, inference and evidence and how these conceptions changed as a result of the formal learning experiences that were provided. As we proceeded to address the constructs of diversity in our population of students, we did so cognizant of the fact that they are not simply of *a* race or *a* culture or *a* gender. They are human beings affected by the interaction of all of these systems. Therefore, our efforts required that we approached our desire to foreground race, culture, and gender understanding of the scientific practices in a new way. Our understandings of elementary students have been enhanced by our attempts to respond to calls to consider race, culture, and gender in *systems of power* (Anderson & Collins, 2007).

We attempted to create a *system of power* underpinning for our work by deliberately addressing the fact that the girls' understandings are situated within a social structure; and acknowledging that the intersection of race, culture, and gender are manifested differently depending on their configuration with the other (Anderson & Collins, 2007). This was accomplished by approaching our research design with the intention of adding the girls' experiences to our understandings instead of merging the understandings; directing it in a manner that allows us in the science education community to understand multiple frameworks. The systems of power approach guided our study in that we situated our research within a specific social structure and designed it to add to the literature base as such, including the learning experiences of low SES, urban, African American primary girls attached to that social structure, not assimilating it nor comparing it to other social structures.

Current empirical work on instruction on the practices of science at the elementary level, such as the work described above, guided our efforts in that we were able to emphasize the most effective pedagogical practices in regards to improving young children's understandings of observation, inference and evidence. We began with the pedagogical practices recommended in this literature, contextualized and decontextualized guided and authentic inquiry; however, as most of that previous work rarely reported the race, gender or SES of the participants, diverse representation was missing in our understandings. This study not only provides implications for the low SES urban district in which we are working, but also contributes to the understandings of instruction on the scientific practices at the elementary level overall by systematically situating the instruction within an underexplored context and with an underrepresented population. Specifically, our teaching efforts were situated in an urban, all-girls' academy with a 99% African American, low SES, student population and contextualized in three units historically emphasized within this school; plants, George Washington Carver and Barbara McClintock.

The purpose of this participatory action research study was to enhance our understandings and practice by exploring the pedagogical approaches that have the greatest potential to start African American girls in low SES schools on the path to learning the practices of science. We sought to unite the existing understandings on elementary science education to those teaching in a diverse educational setting; allowing the underexplored context (e.g., traditions of the school, SES of the students, standards, tests) and the voices of the underrepresented students (African American females) to authentically complicate the process and our understandings. Our pedagogical approach was explicit reflective instruction through contextualized and decontextualized instruction (Clough, 2006). The content focus was observation, inferences and evidence. Contextualizing instruction on observation, inference and evidence has students experiencing some of what doing authentic science is like as these practices become more embedded in the disciplinary core ideas. For example, within a lesson that asks students to explore the relationship between the height of a ramp and the distance a toy car travels, the teacher could draw students' attention to the distinction between observing the height of the ramp and inferring its effect on distance. As students collect evidence, they could be directed to think about how the process is shaping their understandings about the relationships between the height of the ramp and distance traveled. Decontextualized activities on scientific practices are not bound up in science content. This permits the teacher to concentrate solely on the practices of scientists. An example of a decontextualized activity might be students exploring a "black box" in which they needed to determine what was inside a sealed container simply by making observations of what they might hear, smell, or whether or not a magnet was attracted to it. In this case, the students could be directed to reflect on their observations, the inferences they were making for what was inside the black box, and the process of developing an understanding for what was inside the black box from the evidence they could collect from outside.

The overarching question of our research study was, "How can we successfully put twenty-three first-grade African American girls attending a gender school in an impoverished school district on the path to learning the practices of scientists"? To address this question, our research was guided by the following sub-questions:

1. What understandings do these first-grade African American girls in this low SES school have about a) observation and inference and b) evidence in science?
2. What understandings do they gain as a result of participating in a unit that used explicit reflective instruction through decontextualized instruction?
3. What understandings do they gain as a result of participating in a unit that used explicit reflection instruction through contextualized guided and authentic inquiry?

Methodology

Extending our research-based discussions of teaching the practices of scientists to elementary students by adding the experience of teaching in an underexplored context and with an underrepresented population became the starting point for our participatory action research project (Kemmis & McTaggart, 2000). This methodological approach generally involves a spiral of self-reflecting actions that include: planning a change, acting and observing the process and consequences, reflecting on the process and consequences, and then re-planning. Our plan was to design and implement a thirty-day unit that used explicit reflective instruction through contextualized and decontextualized guided and authentic inquiry. The overarching goal of our actions was to enhance our understandings and practice by incorporating the pedagogical approaches that have the greatest potential to start urban African American girls on the path to learning the practices of science.

Participants

Our action research team included one first-grade teacher, two science teacher educators, and two science education doctoral candidates. One of the science teacher educators, Gayle Buck, had been active in the school/university partnership with this district, particularly this one gendered academy, for three years at the time of this project. Her research focus is on increasing our understandings of and efforts in teaching science to an increasingly diverse student population. At the time of the study, Cassie Quigley was a doctoral candidate working as a research assistant for the partnership project. The second science teacher educator, Valarie Akerson, has worked in numerous elementary schools to improve science teaching and learning. Her research focus is on early childhood/elementary pre-service teachers', in-service teachers' and students' views of the nature of science. At the time of the study, Ingrid Weiland was a research assistant working on several initiatives involving nature of science teaching and learning in elementary schools. The classroom teacher was selected due to her prior involvement in the university/school partnership and her desire to become involved in a partnership that directly benefited her students. Due to this involvement, she understood many of the research-based curricular and pedagogical approaches that guided this project. The university educators collaboratively planned the instruction, provided the instructional materials, co-taught, and collected and analyzed the data. The classroom teacher collaboratively planned, co-taught, and provided feedback on emerging understandings and needed revisions throughout the process.

Context

The social structure in which this study took place was one first-grade classroom in a girls' school in a large urban district in a low SES community. The majority of the approximately 350 girls at this school lived locally in one of two public housing developments within four blocks of the school. The student population of the girls' academy was 99% African American and 1% Multiracial. Additionally, 88% of the school population qualified for free lunch. The elementary student participants in this study included 23 African American girls in the first-grade.

Action

There were two phases of the unit: phase 1 was a 10-day explicit-reflective de-contextualized unit, which was based on Akerson's (2010) K-2 study. The purpose of the decontextualized unit was to introduce the practices of observation, inference and evidence and provide experiences for the girls with these ideas (Akerson & Donnelly, 2010). The first day began with a story selected to emphasize one of these practices; a format which was followed throughout the remainder of the first phase of the unit. This story was followed by a discussion of scientists and how scientists use journaling. The girls then designed their own journals, which were used through the remainder of the unit. Over the course of the next nine days, the learning experiences included many decontextualized activities designed to explicitly introduce/reinforce the concepts of observation, inference and empirical evidence. Example activities included: Tricky Tracks, Think Tubes and Oobleck (see Table 1 for complete listing and associated references). Although many of these activities could be used in a contextualized manner as well, we elected to use them in a decontextualized manner by only emphasizing the scientific practices of observation, inference and empirical evidence and not any possible core content connection. At the end of this phase, the girls were interviewed. A full class review discussion of these practices was used to initiate the second phase of the unit.

Phase 2 was a 20-day explicit-reflective contextualized unit. This unit focused on plants and scientific practices. Additionally, George Washington Carver and Barbara McClintock, traditionally introduced and discussed at this grade level were also integrated into this unit. This phase of the intervention was conducted over an eight-week period due to several scheduling conflicts that meant the instruction was not always provided on consecutive days. The first day of the unit began with the girls drawing a plant and using that plant to lead a discussion on what they knew about plants, as well as questions they have about plants. Following this discussion, the students developed investigable questions and considered how they would go about answering the questions. Next, the instructional focus switched to the interviews (noted above) and how the plant discussion did/did not reflect the scientific practices. These initial stages of inquiry into plants served to focus the remainder of phase 2 of the unit. During that time, the girls completed scientific observations of various plants and plant seeds, structured class inquiries on plant growth, as well as researched and completed structured inquiries on hydroponics and lima beans. In addition, they explored how George Washington Carver's ideas about planting changed the way scientists viewed the purpose of soil and how their understandings of the methods of science were challenged and enhanced by Barbara McClintock's observational studies of corn. The culminating learning experience was the completion of a semi-structured experiment on peanut plants. Throughout the unit, the practices explored during the first phase were often explicitly discussed in context of the plant inquiries and core content understandings were emphasized alongside the scientific practices.

Table 1: Timeline of Lessons and Corresponding Practices of Observation, Inference and Empirical Evidence

Day	Learning Goals The first-grade African American girls will…	Activity
1	• distinguish the difference between an observation and an inference.	• Read book Seven Blind Mice (Young, 1992) • Students are introduced to scientific journaling and draw a picture of themselves on the cover • Read book What Do you do with a Tail Like This? (Jenkins & Page, 2003)
2	• discuss the 5 senses as related to observation skills • distinguish between observation and inference	• Discussion about books from Day 1 and how scientists use 5 senses during observations • Draw-a-scientist activity (Lederman & Abd-El-Khalick, 1998) • Dog among spots activity (Lederman & Abd-El-Khalick, 1998) • Old Woman/Young Woman activity (Lederman & Abd-El-Khalick, 1998) • Tricky Tracks Activity (Lederman & Abd-El-Khalick, 1998)
3	• understand how to predict • make observations and inferences	• Discussion about scientists drawings • Opposite Cube Activity (Lederman & Abd-El-Khalick, 1998) • Read Dr. Xargle's Book of Earthlets (Willis, 2002)
4	• understand how to predict • make observations and inferences	• Cube Activity (Lederman & Abd-El-Khalick, 1998) • Think Tubes (Lederman & Abd-El-Khalick, 1998)
5	• understand how scientists infer about dinosaurs • understand how scientists made predictions based on their observations	• Read The Dinosaur Alphabet Book (Pallota, 1990) • Living vs. Nonliving- students sort common items into living vs. nonliving sections
6	• make observations	• Read A Mealworms Life (Himmelman, 2001) • Draw pictures of mealworm • Observe mealworms • Rework drawings of mealworms

7	• understand how to make inferences • understand how scientists collect data	• Read The Extinct Alphabet Book (Pallotta, 1993) • Draw pictures of why the dinosaurs became extinct • Made fossils out of play-dough
8	• understand the difference between solids, liquids, and gases • use their observations to categorize items	• The girls made observations about different common objects and categorized them into solids, liquids, and gases based on their observations
9	• make observations and inferences and categorize data based on it.	• Read Batholomew and the Oobleck (Suess, 1949) • Oobleck Activity (Sneider & Beals, 2004)
10	• make changes to previous inferences based on new data • make observations and inferences	• Sinking vs. floating- students experimented with cubes made of different materials
11	• explore their own initial ideas of plants and develop questions • demonstrate a basic understanding of variables and controls • create their own experiment	• Students draw a picture of a plant and infer what it needs to grow • Discussion of what plants need to grow • Discussion of variables to figure out what plants need to grow
12	• understand what plants need to grow • understand how scientists collect data	• Students set up plant (flowers) experiment with three variables
13	• collect data • observe and infer • improve their initial understandings of plants in light of new evidence	• Students draw observations of plant experiment • Students observe and infer about different types of seeds • Students plant lima beans hydroponically
14	• collect data • observe and infer	• Students draw observations of flower experiment and make inferences about the needs of plants
15	• collect data • observe and infer	• Students draw observations of flower experiment and make inferences about the needs of plants • Students draw observations of lima bean experiment and make inferences about the needs of plants
16	• collect data • observe and infer	• Students draw observations of flower experiment and make inferences about the needs of plants • Students draw observations of lima bean experiment and make inferences about the

	• describe how a culture different from their own views planting and plant growth • collect data • observe and infer	needs of plants • Read Bringing the Rain to Kapita Plain (Aardema, 1992) • Students draw observations of flower experiment • Students draw observations of lima bean experiment and make inferences about the needs of plants
18	• describe Carver's studies on planting • collect data • observe and infer	• Introduce George Washington Carver and his inquiries on soil and purpose of soil • Plant peanut plants • Students draw observations of flower experiment and make inferences about the needs of plants • Students draw observations of lima bean experiment and make inferences about the needs of plants
19	• draw conclusions based on observations and inferences	• Introduce McClintock's observations and inferences • Students find the patterns on corn cobs • Students draw conclusions about flower and lima beans based in their observations and inferences
20-29	• collect data • observe and infer	• Students draw observations of peanut plants and make inferences about the needs of peanut plants
30	• make conclusions based on observations and inferences	• Students make conclusions about peanut plants based on their observations and inferences

Data Collection

To explore the students' understandings about observation, inference and evidence and how these understandings changed as a result of instruction, we administered the YCVOS interview protocol (Lederman, 2009) to the girls on a pre-, mid- and post-unit basis. Prior to each interview cycle, the 23 first-grade girls were read the questions and they individually responded to them in writing or with drawings. These responses were for their own reference during the interview. They were interviewed in small groups no larger than three girls in a manner that would allow them to explain, expand or refine their preliminary written responses. Each participant group was interviewed three times over the course of the project (pre-, mid- and post-unit). A total of 30 small group interviews were completed. This small group format was preferred because it offered us access to these girls' thoughts on the practices we were emphasizing in their own words rather than requiring simple responses to our words. This attribute is particularly important for this study involving very young girls who are members of underserved populations because it results in a more comfortable atmosphere for the girls' to reflect with each other (Reinharz, 1992). We followed the interview protocol (Lederman, 2009) shown to be appropriate and valid for young children. Sample questions included: (1) Can you tell me something you know about science?, (2) How do scientists know that dinosaurs really lived since there are no dinosaurs around anymore and no one has ever seen them? In addition, the interview had the girls completing a simple task; making an observation and inference about two different size paper helicopters falling, one at a time, and responding to several questions on the practices inherent in the task. Sample question included: (1) Was what you watched a scientific investigation?, (2) Why or why is not a scientific investigation?

To further explore and track the development of the elementary girls' understandings, we collected copies of their science journals. The journals were structured to have the girls reflect, in writing and pictures, on observation, inferences and empirical evidence. Furthermore, we videotaped each science lesson of the unit to allow us to track instruction over the course of this unit. We used the videotapes to capture the debriefs and interactions with the girls during the unit. For example, as one student drew a scientist observing a phenomenon, the researcher asked her if the scientist was making inferences as well. In addition, the research team reviewed these videotapes to assure that we were using explicit reflective instruction through contextualized and decontextualized approaches to teach the practices of science.

Analysis

Interviews were transcribed and coded using the scoring guide for the YCVOS. This scoring guide used two categories: naïve and informed. We coded their verbal responses for (1) whether they understood that science involves gathering empirical evidence and data in a systematic and rigorous manner, and (2) whether they could discern the difference between observation (based on five senses) and inference (what someone thinks the observations reveal).
This coding system was also used for a content analysis on the journal entries from the students. Content analysis is a systematic, replicable technique for compressing large quantities of text into fewer content categories based on explicit codes (Weber, 1990). We coded all copies of student work and classroom observations throughout the intervention, noting whether and when students improved their understandings. We coded their writing and responses for (1) whether they were describing the practice accurately, and (2) whether they attributed the practice to the work of scientists. Lastly, we analyzed the videos to ensure the intended practices were taught in an explicit and reflective manner and that the girls' were reaching and understanding these practices. The researchers met together and compared their findings. All discrepancies were discussed and resolved.

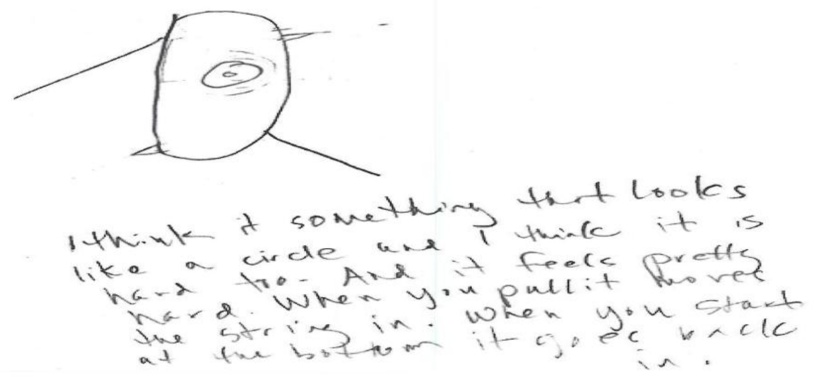
Findings

In this section, we report the findings for the three research sub-questions: (1) What understandings did the first-grade African American girls we taught have about a) observation and inference and b) the empirical evidence? (2) What understandings did they gain as a result of participating in a unit that used explicit reflective instruction through decontextualized instruction?, and (3) What understandings did they gain as a result of participating in a unit that used explicit reflective instruction through contextualized guided and authentic inquiry? These findings are further organized by the specific practices. They are presented in a manner that demonstrates the understandings of all of the young girls during the YCVOS interview process and classroom activities; using percentages of informed responses for the groups and individual quotes or written documents as supporting evidence. All names are pseudonyms to protect confidentiality.

Observation and Inference

During our first round of YCVOS interviews, 29% of the first-graders revealed informed understandings in regards to observation and inference (see Table 2). For example, one girl was able to make an inference for why the dinosaurs are extinct when she stated, “It was too cold for them” (Connie, Interview, 09/08). Similarly, Dehlia inferred the “little dinosaurs were eaten by the bigger dinosaurs” (Dehlia, Interview, 09/08). During the decontextualized Think Tube lesson, many of the girls were able to make observations and inferences for what was inside the tube (Field Notes, 09/14). Layla described her observations and drew her inferences for what was inside the tube. She read her journal entry to the researcher noting, “I think it is something that looks like a circle and it is hard too. And it feels pretty hard. When you pull [the string], it goes in. When you start at the bottom it goes back in again” (Layla, Journal, 09/14) (Figure 1).

Figure 1. Layla’s journal entry showing her observation and inference during the decontextualized “Think Tube” lesson.



I think it something that looks
like a circle and I think it is
hard too. And it feels pretty
hard. When you pull it moves
the string in. When you start
at the bottom it goes back
in.

Here, Layla was making observations and inferences. Similarly, Keira read her entry, “It think it’s a ball because it sounds like a ball and rolls like a ball” (Keira, Journal, 09/14; Field Notes, 09/14). Janay even made an inference on her own while observing mealworms: “The black one ate more food, that’s why it is bigger” (Janay, Journal 09/16). Importantly, although the girls were not differentiating between observations and inferences, they were able to make observations and infer from those observations.

After the decontextualized unit, 62% of the girls revealed informed understandings of observation and inference during the YCVOS process (see Table 2). The girls who revealed informed views of observations vs. inferences explained how to observe (taste, sight, touch, and smell) and then described how observations may provide clues to help a person better understand something. Of the girls who did not demonstrate this informed level of understanding, they (1) could not describe nor make observations, or (2) were able to make observations but were not able to describe how these observation informed their ideas or inferences. For a few, their experiences with making observations seemed to confuse them and for some, even though they did not have naïve views prior to the unit, they revealed this view afterwards.

Our analysis revealed that during the contextualized unit, many of the girls were able to successfully make observations (Field Notes, 10/06). For example, the girls observed by counting the number of seeds. During the lesson, Connie wrote, "I have 4 yellow seeds and 4 lima beans. [The seeds] are round" (Connie, Journal Entry, 10/06). In their journals, they noted scientists also observe. For example, Dehlia stated, "Scientists count to observe" (Dehlia, Journal Entry, 10/07). Leah described her own observations of the plants during her experiment and discussed her inferences for why her plant was not growing (Field Notes, 10/06). Despite these apparent successes during the contextualized unit, there was a decrease (27% informed) in the percentage of girls demonstrating informed views during our final YCVOS interview (see Table 2). Some of the girls did maintain their informed views. Connie revealed an informed view of observations vs. inference at the end of the contextualized plant unit when she stated, "…she is a scientists cause she searched everywhere for birds- she observed with her eyes. She figured out what the birds were eating by her observations" (Connie, Interview, 10/22). In this way, Connie is able to differentiate between an observation and inference, as well as apply this to a new situation. Unfortunately, several other girls did not maintain their informed views. Overall, these girls could describe observations, such as observing plants, but could not describe how scientists use observations to make inferences. Those who demonstrated naïve views at the beginning of the contextualized unit maintained these views. For example, Janay maintained her naive view of observation vs. inference from the decontextualized unit to after the contextualized plant unit and described observations as, "scientists make observations by looking" (Janay, Journal Entry, 10/06) but could not describe the difference between observations vs. inference. Brianna still could not describe what observations were or how scientists used them.

Table 2. Percentage of Girls' Attaining an Informed Level of Understanding Over the Course of Instruction

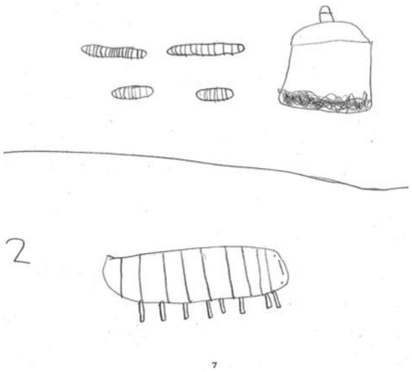
Scientific Practice	Informed Level of Understanding	Percentage of Students Demonstrating Informed Level of Understanding		
		Pre-Intervention	Post-Decontextualized	Post-Contextualized
Observation and Inference	Student can discern the difference between observation (based on five senses) and inference (what they think the observation means)	29%	62%	27%
Empirical Evidence	Science involve gathering evidence and data in a systematic and rigorous manner	33%	33%	56%

Empirical Evidence

During the first round of YCVOS interviews, 33% of the girls revealed informed understandings of empirical evidence in science (see Table 2). When asked if the bird lady was working like a scientist, Nali stated, “Yes…she wanted to know which sizes went with which food” (Nali, Interview, 09/08). Of the students who did not reveal such informed views, some responded they simply did not know or responded with a nonsequitor. Or, when asked how a woman observing birds could answer her research question, Mary answered, “She could ask her mom if she could get a bird,” and “Some people are scared of birds” (Mary, Interview, 09/08). Some of the girls revealed what is considered naive views of empirical evidence, for example when Lauren was asked how the bird woman could answer her research question, she stated, “Some people whistle and then the birds talk back” (Lauren, Interview, 09/08). Connie stated, “Yes, because she was looking at the different birds” (Connie, Interview, 09/08).

During the decontextualized unit, we provided the girls with many opportunities to experience the empirical evidence (see Table 1 and intervention section for complete explanation). Some of these lessons included collecting data through observations of living and nonliving things and making predictions of the growth of mealworms. Ebony demonstrated her ability to make observations and record those observations in her journal (Field Notes, 10/22; Ebony, Journal, 10/22). She also made a prediction of what she thought would happen to the mealworm over the next couple of days (Ebony, Journal, 10/22) (Figure 2). Yet, after this unit, we did not realize a gain in informed understandings (remaining at 33% informed) throughout our YCVOS interviews (see Table 2). Anna’s informed view was showcased with the following statement, “because she loved beaks and she observed, she looked at their beaks, she thought …they had thin beaks, long beaks” (Anna, Interview, 10/22). However, Jenny continued to reveal a naïve view when she said the bird woman was acting like a scientist, “'cause she feeds the birds” (Jenny, Interview, 10/22). Layla demonstrated her naive view of empirical evidence when she stated, “She travelled all around the world and watched [the birds]” (Layla, Interview, 10/22).

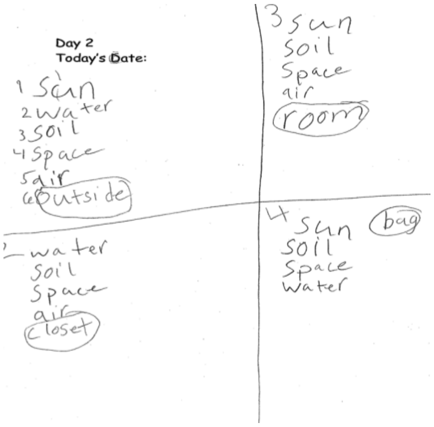
Figure 2. Ebony’s journal entry showing her data collection of the mealworms. The top picture is her observations. The bottom picture is her prediction of the mealworm’s growth.



During the contextualized plant unit, the girls described empirical evidence when they were writing in their journals about how they were acting like scientists when making predictions. The girls also described the specifics of making predictions and were able to do so.

For example, Lelia predicted her plant, which was in the closet, would grow a little (Field Notes, 10/12) (Figure 3).

Figure 3. Layla's journal during the contextualized plant unit. She describes the four different experiments she and her classmates set up.



Andrea stated, "It will not grow in a bag. We are not giving it air and not giving it space" (Andrea, Journal Entry, 10/12). Additionally, the girls' created an experiment to discover what plants needed to growth. They created four experiments with controls and collected data on their plant grow (See Figure 2). For example, when thinking how to control for sunlight, Layla said, "If we put it in the closet, it may not grow" (Layla, Journal Entry, 10/12). After this contextualized plant unit, 56% of the girls revealed informed views of empirical evidence (see Table 2). Examples of statements from girls who revealed informed views of science after instruction included Andrea who stated a woman described to her during the YCVOS interview was acting like a scientist "because she was watching what the birds were eating" (Andrea, Interview, 12/08). Connie demonstrated a more informed understandings after the contextualized unit. She stated in her final interview, "She is a scientist 'cause she searched everywhere for birds- she observed with her eyes" (Connie, Interview, 12/08).

Implications

As a participatory action research team, we actively worked within this urban classroom to enhance the young children's understandings of some of the practices of scientists and start their path to science literacy. Together with the classroom teacher, we explored the academic growth of the African American girls and deepened our understanding of their learning experience. As a result of our efforts to develop and implement educational experiences based on prior empirical studies on teaching scientific practices to elementary students, an increasing number of the girls' understandings of observation, inference and the empirical evidence did reach the informed level *at some point* during the full unit. The findings from our study support much of the current research on enhancing young children's understandings of observation, inference and the empirical nature of science; but it also questions some of the assumptions derived from this previous work. We question why so many of the girls did not reach the informed level of understanding? Our findings enhance the current literature base in this area by furthering the discussion on the needs of young African American girls from low SES contexts. These aspects of the experience are further discussed below.

We found that similar to prior research on young children's understandings of these practices (e.g., Akerson & Donnelly, 2010; Mertz, 1995, 2004) many of our first-grade African American girls entered the instruction with naïve understandings and were able to develop more informed understandings are the result of explicit instruction. Most of our girls did not hold informed conceptions of observation and inferences prior to instruction, but many improved these understandings following the decontextualized instruction. Likewise, most of the first-graders did not hold informed understandings of the empirical evidence prior to instruction, but improved their understandings throughout the contextualized instruction. This experience reinforced and renewed our understandings of these practices by using a combination of decontextualized and contextualized instruction. However, by studying the girl's understandings before and after the decontextualized and then before and after the contextualized sections of the unit, we gained new understandings of how these various approaches may also hinder those understandings for young children. For example, some of the children further refined their ideas about the empirical evidence through the contextualized instruction; however, that instruction appeared to complicate the ideas for the students in regards to inferences. We now reflect on how we collaboratively structured those sections of the unit in order to explain the differences; allowing us to improve our use of a combination of decontextualized and contextualized instruction.

We implemented decontextualized instruction on observation, inference and empirical evidence in order to introduce them disconnected from any science content that may be unfamiliar to our students. This permitted us to focus solely on the practices (Clough, 2006). We addressed observation and inference by having the young girls complete such activities as Tricky Tracks and Think Tubes (Lederman & Abd-El-Khalick, 1998). Prior work has demonstrated that elementary children are able to distinguish between observation and inferences in these activities (e.g., Akerson, Weiland, Pongsanon & Nargund, 2011). Our findings further support that work. The decontextualized approach of completing activities such as Tricky Tracks without addressing other science content (e.g., correct types of tracks or animal behavior) allowed the girls to clearly *observe* the animal tracks and *infer* in a nonthreatening manner. The distinction between what they observed and inferred was readily understood by many of the young children (29% to 62% informed). In contrast, we conclude that this same decontextualized approach did not work in regards to evidence. We introduced the empirical evidence with such activities as Oobleck (Sneider & Beals, 2004), making fossils out of play dough, and studying mealworms. Within these activities, the girls collected observational evidence in a relatively systematic and rigorous manner. The class discussions during these activities centered on observations, inference and empirical evidence with an emphasis typically being placed on observation. Upon reflection, we realized that the short periods of time we allowed for these activities, often trying to get two or more activities done in one day, integrated discussions of several different practices, unusual or unfamiliar objects, and the lack of authentic discussions of the evidence prevented the young girls from reaching informed understandings about empirical evidence. As we work with their teachers to implement these strategies throughout the school, we will caution them as to the time and attention that is necessary for these young girls to realize how the observations and inferences they make become actual evidence. We also wonder if the connection to fascinating scientific phenomena during our decontextualized instruction (Oobleck, mealworms) may have distracted the girls' attention from the specific practice. This distraction could be adjusted by designing decontextualized instruction on evidence that involves simple mysteries involving everyday objects.

Contextualized instruction allows for a higher level of complexity as the concepts are applied to other contexts as they are connected to science content (Clough, 2006). This instructional approach resulted in increased understandings about the empirical evidence (33% to 56% informed). We contend that by extending instruction and having the young children actually gather evidence and come to conclusions we furthered their understandings in this regard. In contrast, it appears as if the added complexity of the contextualized unit, and the increased level of involvement in discussions on inferences being made by actual scientists, resulted in misunderstandings in regards to inferences (62% to 27% informed). Perhaps our instruction did not sufficiently recognize or consider the girls' preconceptions on the contexts involved in contextualizing instruction into current social science units at the school site (e.g., George Washington Carver and Barbara McClintock). We question whether our focus on diverse scientists that are presented as role models to this diverse population prevented further exploration of inferences due to the fact that these young children could not see them as stating anything less than “truths.” As a result of our inquiry, we are left wondering if contextualizing inferences into science content, and particularly social science concepts, added a level of complexity that was too high for our first-graders. By intentionally including context in our instruction of the students, we complicated the process with the relationship between the students, science, and the larger community. For the most part, the increases in understandings that resulted from contextualized instruction that did not meet our expectations, and in some, such as with inferences, seemed to work counter to our goals. The reasons for such findings are not as clear for us as those that resulted from the decontextualized approach and empirical evidence. We have come to realize that this literature on contextualizing instruction includes many unexplained or unexplored understandings. Based on our findings, we will address contextualizing instruction on inferences separately from the other practices. We will work to design a contextualized approach that involves a level of content that is more easily understood by the first-grade African American girls.

Future Research

Prior research has shown that explicit reflective instruction through contextualized and decontextualized approaches does enable elementary children to improve their understandings of science and the practices within (Akerson & Donnelly, 2010; Akerson & Volrich, 2006). The reflections inherent in this current study authentically complicate our previous efforts by further exploring a combination of decontextualized and contextualized explicit instruction for these elementary-aged girls. At this point, we have initial understandings about the impacts of our efforts, but the reasons for these impacts need further exploration if we are to maximize the learning opportunities for these young girls. Specifically, further research is needed to enhance our understandings of elementary children's understandings of inferences. As an understanding of inferences is often the difference between adequate and informed understandings of observations and inferences, we feel such understandings are critical. Can we realistically have elementary children apply their budding understandings of inferences to the work of contemporary scientists? Research is also needed to help explain whether situating the contextualized instruction into social science complicates understandings to a level that is counterproductive. Highlighting diverse scientists (Basu & Baron, 2007; Zacharia & Barton, 2004) and situating instruction into culturally relevant topics (Boullon & Gomez, 2001) are strategies recommended for young African American girls. As a result of our study, we question whether there are aspects of this approach that hinder other recommended strategies. Do these approaches enhance emotional engagement with science while hindering cognitive engagement with the practices of scientists? Are there specific approaches to these strategies that enhance both types of engagement? Entering the classroom with this first-grade teacher and experiencing what it is like to implement the empirically based strategies currently being emphasized in our profession has authentically complicated our practice. A complication that is necessary if we are to enhance elementary African American girls' understandings. In addition, we entered into a diverse context to explore these understandings. As noted above, we found that much of the pedagogical strategies currently being explored in science education support the learning needs of young African American girls from low SES contexts to an extent. There were, however, aspects of those strategies that we found did not support their learning. As we question the various aspects of instruction that appeared to be counterproductive, we need to also question whether it was the strategies within this specific context that lead to these results.

Understanding how to successfully incorporate science and engineering practices into K-12 education at increasing levels of proficiency is "one of the most significant challenges for the successful implementation of science education standards" (Bybee, 2011, p. 39). Research has provided us with valuable understandings in this area. Such understandings, however, will be limited as long as our classroom-based studies persist in ignoring gender, race, and culture. We designed this study in a manner that would allow the students and context to inform our understandings of enhancing young girls' early understandings of the practices of scientists. Our findings extend current understandings of how to address that challenge by supporting some of the previous findings and raising questions in regard to others. By exploring pathways to scientific practices with elementary African American girls in a low SES urban school, we hoped to understand, and ultimately respond to, logistical and institutional challenges associated with day-to-day teaching and learning in urban, low SES elementary schools. As we move forward, we will maintain the aspects of our instruction that supported these young African American girls' learning pathways in regards to the practices of science. This is explicit instruction that scaffold back and forth along a continuum from decontextualized to highly contextualized instruction. We will, however, systematically explore changing the aspects of this instruction in regards to observation and inferences. We will begin by contextualizing it within scientific content and not social science. From there, we can further question whether it was the social science instruction, if indeed we find the changes lead to different result, or the girls' reluctance to question their role models' understandings as anything less than sure knowledge. In essence, we intend to further integrate the practices into this diverse school setting, thereby creating opportunities for increased learning overall.

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