LEARNING TO "SEE" SOUND:

AN INVESTIGATION INTO THE INTELLECTUAL AND LINGUISTIC RESOURCES THAT URBAN MIDDLE SCHOOL AFRICAN AMERICAN BOYS UTILIZE IN THE PRACTICE OF REPRESENTING SOUND TRANSMISSION

A doctoral dissertation

submitted by

Christopher G. Wright

In partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in

Education

TUFTS UNIVERSITY

May, 2011

Adviser: Dr. Bárbara M. Brizuela

Abstract

This research examines the intellectual and linguistic resources that a group of African American boys brought to the study of the science of sound and the practice of representation. By taking a resource-rich view of the boys' linguistic and representational practices, my objective is to investigate children's abilities in producing, using, critiquing, and modifying representations. Specifically, this research looks to explore and identify the varieties of resources that African American boys utilize in developing scientific understanding. Using transcripts from group sessions, as well as the drawings produced during these sessions, I utilized a combination of discourse analysis to explore the boys' linguistic interactions during the critique of drawings with a focus on the boys' manipulation of line segments in order to explore their representational competencies.

Analysis of the transcripts and the boys' drawings revealed several important findings. First, elements of *Signifying* were instrumental in the group's collective exploration of each other's drawings, and the ideas of sound transmission being represented in the drawings. Thus, I found that the boys' use of *Signifying* was key to their engagement win the practice of critique. Second, the boys' ideas regarding sound transmission were not fixed, stable misconceptions that could be "fixed" through instruction. Instead, I believe that their explanations and drawings were generated from a web of ideas regarding sound transmission. Lastly, the boys exhibited a form of meta-representational competency that included the production, modification, and manipulation of

notations used to represent sound transmission. Despite this competency, the negotiation process necessary in constructing meaning of a drawing highlighted the complexities in developing a conventional understanding or meaning for representations.

Additional research is necessary for exploring the intellectual and lingustic resources that children from communities of color bring to the science classroom. The objective of this research was not to highlight a single intellectal and linguistic resource that educators and educational researchers could expect to witness when working with African American boys. Instead, the objective was to highlight an approach to teaching and learning that investigated and highlighted the resources that children from communities of color have developed within their communities and from their varied life experiences that may be conducive to scientific exploration and language. Recognizing that all children bring a variety of resources that can be utilized and further developed in order to expand their understandings of scientific concepts or a representational practices must be continually explored if we are to begin the process of addressing inequitable access to science opportunities.

DEDICATION

"Bringing the gifts that my ancestors gave, I am the dream and the hope of the slave. I rise, I rise, I rise." -- Maya Angelou

This dissertation is dedicated in memory to my father, Mr. George Wright, Jr. (1949-2009). As I reflect on your continued impact on my life, I thank the Creator for such a blessing. In you, I always had my role model. I hope that I am living the dream that you had for me when you first held me in your arms, looked into my eyes, and dedicated a large part of your life to my well being. Thank you.

In addition, I dedicate this accomplishment to Maurice Floyd Ambush, Allen J. Ambush, Harold Burris, Howard Boyd, and Joel White. These strong, powerful, and inspirational African American men have also sacrificed so much in order to pave the way for younger African American males like me. The examples of fatherhood, being good husbands, being good family men, and brotherhood continue to inform my approach to life.

To my Brothers, Chris A., Ragz, and Saeed., I challenge us to look towards these men, "our lineage," and to reflect on our place within this family tree. I challenge us to reflect on the lives that we impact on a daily basis and the challenges that await us.

Finally, I especially dedicate this work to Jecha, Jerah, CJ, Fred, Malcolm, Tyson, and Raggy because YOU are the inspiration for this research. As the great Maya Angelou expressed, "YOU are the dream and hope of the slave."

ACKOWLEDEMENTS

"It is this belief in a power larger than myself and other than myself which allows me to venture into the unknown and even the unknowable" -- Maya Angelou

The completion of this dissertation is by no means an individual accomplishment. It would not have been possible without the energy and support from family, friends, and mentors. I am grateful to my advisor, Bárbara Brizuela, for the support and guidance she has given me through the years, but especially for the time, expertise, and commitment she provided during the dissertation process. I also acknowledge and thank my dissertation committee for contributing their time and expertise to my work: Analucia Schliemann, Ann Rosebery, and Chris Rogers.

I am most grateful to my second family, the people of Chèche Konnen, who have loved, cheered, and inspired me throughout these many years and whose support has given me this opportunity. I am especially grateful to Ann Rosebery, Beth Warren, Brian Wright, Carol Wright, Curtis Killian, Eli Tucker-Raymond, Folashade Cromwell-Solomon, Josiane Hudicourt-Barnes, and Megan Bang.

I could not have completed this study without the help and support of my friends and colleagues at the Center for Engineering Education and Outreach and the Tufts University Education Department. First, the cohort of MSTE students I entered this program with has been the biggest supporters, motivators, role models, and friends that one could hope to work with. Thanks to Brian, Kristen, and Mary. To my friends at the CEEO, I have appreciated and valued the previous

5 years with all of you. I have really appreciated the bright and cheery smiles upon entering the office, being a member of a multiple championship softball team that helped to momentarily divert my attention, the random, but often amusing "serious play" opportunities, and just the eye-opening opportunities for utilizing technologies and robotics within the lives of many deserving youth. To my friends at PACE, Linda, Roberta, and Annie, thank you too for the bright smiles and constant encouragement. In addition, I would like to give a special thank you to Sabina Vaught for all your support, encouragement, and mentoring.

Last, but not least, I must take a moment to give a huge thank you to the strong women in my life. Mom, you have been an unwavering source of encouragement, support, motivation, spiritual leadership, and love throughout this process and throughout life in general. None of this would have been possible without the warmth of your thoughts, arms, and prayers constantly guiding me. To Shirley Ambush, thanks for just being Mi-Mi! To my "second mothers," Pamela Ambush Burris and Elizabeth Johnson, I thank you too for the constant prayers, support, ad yes, babysitting!! To my sisters, Carrie, Michele, and Margaret, much love and thanks. To my little ones, Jata, Kai, Kendall, Maiya, and Angel, the world is yours and if you ever need a helping hand, I am definitely there for you.

Finally, I would be remiss if I did not express the utmost respect and love for an amazing woman, my wife, Vondaleir N. Wright. I immediately think about one my favorite gospel songs by Marvin Sapp, "Never would have made it, never could have made it without you!" Words cannot express the gratitude that I have

for such a supportive, adventurous, and enthusiastic partner. You have been a consistent “keeper of my dreams,” and I am truly blessed. Thank you!!

Table of Contents

List of Tables

List of Figures

CHAPTER 1:

INTRODUCTION TO THE RESEARCH

This dissertation presents research that examined the intellectual and linguistic resources that a group of African American boys brought to the study of the science of sound and the practice of representation. Five boys, ages 12-13, from an urban neighborhood in Baltimore, Maryland, participated in a one-week, student-centered exploration of sound transmission, as well as pre and post-exploration interviews. This chapter describes the research problem, the rationale for the study, the goals for the study, and specific research questions addressed.

Research Problem

Access to high-quality opportunities for learning in science and mathematics has been described as a 21st century civil rights issue (Moses & Cobb, 2001; Tate, 2001) with important implications for the kinds of educational and work opportunities that will be available to children from communities of color[1] from urban districts throughout the United States. Historically, these children have been limited in their access to high-quality opportunities in science. For instance, things such as obsolete science infrastructure in urban schools, outdated curricula materials, narrowly focused testing, and fragmented teacher preparation and development have been ill-equipped to effectively address and nurture the intellectual strengths that children from communities of color bring to

[1] I use the "traditional" United States' (U.S.) term "children from communities of color" to represent children from racial or communal backgrounds other than European descent. Despite my use, "children from non-dominant communities" is also appropriate because it explicitly acknowledges historical and current issues of power and social inequalities (Gutiérrez, 2008).

the study of science (Elmesky & Tobin, 2005; Kozol, 2005; Lynn, Bacon, Totten, Bridges, & Jennings , 2010; Seiler, 2001). An integral common thread limiting this access is the persistence of deficit-oriented perspectives towards the ways of thinking, doing, and talking that children from communities of color often exemplify in relation to academic disciplines, including science (Warren, Ogonowski, & Pothier, 2005). Deficit perspectives, which continue to pervade policy and practice, have been generated from ideas presented in earlier theories, such as the genetic deficit theory and cultural deficit theory (Erickson, 1987; Ladson-Billings, 1998; Solórzano, 1997). These theories maintained that white people were genetically superior to non-white people and viewed cultures and environments outside of mainstream Euro-American, as inferior. I contend, with others (Davis, 2003; Noguera, 2003; Shealey & Lue, 2006), that these deficit perspectives have been tacitly maintained within the current educational environment through the theoretical perspective of research with "at-risk" children. This perspective insists that "at-risk" children are cognitively deficient due to perceived community deficiencies (e.g., chronic poverty situation, bad neighborhoods, and poor schools), family limitations (e.g., being "minority," poor parenting skills, single-parent households, and lack of structure or rules), and demonstration of adverse behaviors (e.g., poor social skills and school performance, non-standard English; Banks, 1993; McMillian, 2004). Unfortunately, the policies, beliefs, and instructional approaches that have emerged from these perspectives perpetuate a lack of access to high-quality opportunities in science for children from communities of color "educated" within

most urban districts (Songer, Lee, & Kam, 2002). Thus, the challenges that teachers encounter are often met with teacher-centered instructional practices that are dominated by giving information through whole-class lectures, worksheet assignments, administering tests, and behavior modification techniques while settling disputes or punishing noncompliance, and giving grades (Ferguson, 2001; Haberman, 1991; Houle & Barnett, 2008). The opportunity to express ideas through extended talk or other modes of communication (e.g., drawing, model construction) are rarely provided within these environments.

Furthermore, I believe that the educational research community has played a prominent, and largely unexamined role in informing the pedagogical approaches that dominate science classrooms heavily populated with children from communities of color. Within the educational research community, the intellectual and linguistic resources of African American children's, the specific focus of this study, ways of knowing and talking have often been absent and unnamed within science education research (Azevedo, 2000; diSessa, 2004; diSessa, Hammer, Sherin, & Kolpakowski, 1991; Sherin, 2000) or named and devalued or explicitly compared to a "standard" way of knowing and talking, as exhibited by their Caucasian counterparts (Lee, Fradd, & Sutman, 1995; Silk, Schunn, & Cary, 2009). I suggest that we cannot totally understand the complexities of children's learning and development in science until there is significant research done within diverse communities, while incorporating new theoretical and methodological approaches that do not position these communities as deficient, but as sources of scientific knowledge (Brown & Reveles, 2005; Lee,

2003; Martin, 2009; Nasir, 2000). In order to develop comprehensive theories of learning within science, children from varied communities and life experiences must be included, as well as valued, in the conversation and research. Incorporating a methodological approach that uses student talk and their production of drawings to investigate a group of African American boys' intellectual and linguistic resources that relate to their study of science, this study looks to add to the educational research literature by specifically valuing the boys' abilities in constructing scientific understanding, as well as representational understanding regarding sound transmission.

This dissertation specifically focuses on the experiences of African American boys because "as a group, the cumulative consequences of school failure are most severe for this group of students... and ... this enormity of school failure has created a rip tide of negative results for Black students and society as a whole" (Howard, 2008, p. 2). So, with this study, I do not diminish the plight of children from other communities of color, but I do personally connect with the difficulties that many African American boys contend with in urban public schools. For instance, the 2007-08 national graduation rate for African American males was 47%, while the graduation rate for their White peers was 78% (Holzman, 2010). Trends in Baltimore City, the specific location for data collection for this dissertation, are even more disturbing regarding the "success" of African American male students. In 2003-04, the graduation rate in Baltimore City for African American males was 31% (Holzman, 2006), while in 2007-08 the graduation rate slightly increased to 35% (Holzman, 2010). Recently, the

performance of African American males has been credited as the driving force behind the overall improvement in Baltimore City's graduation rates (Bowie, 2010), while the males' graduation rate increased to 57% in 2010. Despite this improvement, the rate still lagged behind the graduation rate for all Baltimore City students at 66% and the rate for African American females at 74%. When specifically examining the national trends in science achievement, a similar story unfolds. Although African American males comprised 9% of the United States' public school enrollment in 2006, they comprised less than 3% of the students in AP science and mathematics courses (Pérez, 2010). Science results from the National Assessment of Educational Progress (NAEP, 2009) highlight that 8th grade African American males averaged 125 point out of a possible 300 points, the lowest average for any demographic of students (see Table 1). Table 2 displays a similar pattern when specifically examining Baltimore City 8th graders' performance on the Maryland Middle School Assessment (MSA) for science (Maryland Report Card, 2010). These tendencies, and similar patterns within larger urban school districts, have prompted scholars, such as Tyrone Howard (2008), to ask the pointed question, *"Who really cares?"* in regards to African American males' plight in K-12 schools. The aforementioned trends and questions have informed the development and purpose of the current research.

Table 1

2009 Science scores from the National Assessment of Educational Progress - 8th Grade

Gender	Year	White Avg. Scale Score	Black Avg. Scale Score	Hispanic Avg. Scale Score	Asian/ Pacific Islander Avg. Scale Score	American Indian Avg. Scale Score	Unclassified Avg. Scale Score
Male	2009	163	125	133	161	143	150
Female	2009	159	126	129	157	134	149

Table 2

2010 - 8th Grade Maryland Middle School Assessment (MSA) Science Results: Percentage of Students Classified as Basic[2]

Gender	Year	White	Black	Hispanic	Asian/Pacific Islander	American Indian
Male	2010	46.6	67.9	61.2	35.7	66.7
Female	2010	52.7	65.7	63.3	29.4	N/A

Children from communities of color, specifically African American boys for the purposes of this study, bring various intellectual and linguistic strengths to the exploration of science that may, at times, appear far removed from settled, expected modes of scientific thinking in school (Ballenger, 2004; Hudicourt-

[2] Students as the "basic" level need more work to attain proficiency. "Basic" level students are described as using minimal supporting evidence. Their responses provide little or no synthesis of information, such as data, cause-effect relationships, or other collected evidence with little or no use of scientific terminology (Maryland Report Card, 2010).

Barnes, 2003; Warren et al., 2005). When students' strengths are recognized, taken up, and developed by teachers, they have the potential to expand the science learning within a science classroom, and at the same time to invite those children who have been historically marginalized by school science into a community of scientific thinkers and learners (Rizzuto, 2008; Warren & Rosebery, 2008). Thus, analyzing the heterogeneous resources with which children make sense of scientific phenomena will, I argue, assist in expanding the science education field's understanding of what is intellectually meaningful and generative within science classrooms. This dissertation looks to provide empirical evidence for the varied intellectual and linguistic resources that African American boys bring to the discipline of science, and how these resources support learning complex ideas and practices within the group. This research will, therefore, offer an important counterpoint for deficit-oriented perspectives and contribute to a foundation of knowledge for remedying inequitable practices in science education for children from communities of color.

Rationale for the Study

This study specifically examines the meta-representational competence (MRC; diSessa & Sherin, 2000) demonstrated by a group of urban, 7th and 8th grade African American boys, as well as the intellectual resources that the boys brought to the practice of representations as they explored the scientific phenomenon of sound transmission. Focusing on MRC, I investigated the children's abilities "to select, produce, and productively use representations, but

also the abilities to critique and modify representations and even to design completely new representations" (diSessa & Sherin, 2000, p. 386). Until recently, studies within the MRC framework have primarily focused on identifying representational competence as exhibited by individual students (Azevedo, 2000; diSessa et al., 1991; Sherin, 2000). Current conceptualizations of MRC have expanded to also recognize the practice of representation and the development of criteria for a "good" representation as being "socially mediated, open to change, and negotiated within ongoing activity." (Danish & Enyedy, 2007, p. 6) In this study, I contend that the negotiation process in which the boys engage in within their local practice of representation is fundamentally a cultural process (Gutiérrez, 2002; Nasir, Rosebery, Warren, & Lee, 2006; Rogoff, 2003). By culture, I mean the "constellation of practices historically developed and dynamically shaped by communities in order to accomplish the purposes they value (Nasir et al., 2006, p. 489). Thus, this study examined the common and varied practices used by a group of African American boys as they engaged in producing, interpreting, and critiquing representations of sound transmission. I would argue, along with others (Bang & Medin, 2010; Hudicourt-Barnes, 2003; Nasir, 2005), that the identified practices are not outcomes of the boys being African American, but are ways of representing the world developed through their participation in common experiences, activities, and values within their local community. For instance, in this dissertation, I will highlight the boys' use of *Signifying*[3] as a method for engaging each other in conversation regarding their

[3] Signifying as the socio-linguistic practice with a tradition in the African American community will be differentiated from signifying - a core element of semiotics (Chandler, 2007) - by the use

drawings of sound transmission. Although *Signifying* is a linguistic practice with a tradition in the African American community, the group of boys within this study appropriated its use to function as a resource for socially exploring sound transmission and the representation of the phenomenon. *Signifying* is not an outcome of being African American, but a result of the participation of communities of African Americans in common historical experiences and practices.

Focusing on external representations, I call attention to Enyedy's (2005) definition of representation as "the act of highlighting aspects of our experiences and communicating them to others and ourselves" (p. 427). This conceptualization of representing as a practice made sense for this study, as I looked to examine how the boys negotiated their shared experiences with sound transmission and their uses and interpretation of drawings, in order to highlight and communicate specific aspects of the scientific phenomenon. As the boys produced and interpreted representations that focused on specific aspects of sound transmission, I conjectured that various aspects of the boys' understandings of sound transmission, how to represent those understandings, and the negotiation process used to explore the science and the representations would become explicit and further refined.

My focus on MRC is informed by my experience of how representations are typically employed in science classrooms. Children are frequently asked to engage with scientific ideas through images, ranging from drawings and maps to graphs and diagrams. For instance, children in science classrooms frequently

---

of capital "S" for the socio-linguistic reference.

encounter diagrams of the water cycle, free-body diagrams, orthographic projection drawings, and images of the engineering design process. Unfortunately, children's engagement with visual images in science is often structured by the assumption that the images are self-explanatory and help make the phenomena easier to understand (Lowe, 2000). This assumption supports the idea that visual images, especially those found in disciplines that are supposedly objective in nature (e.g., science, engineering, and mathematics), have inherent meanings that children are expected to comprehend and interpret with appropriate instructional support. This idea contradicts the underlying theoretical belief of this study, as well as studies within a MRC framework (diSessa, 2004; diSessa & Sherin, 2000), that individuals develop ways of conceptualizing, representing, evaluating, and engaging the world, as they negotiate varied repertoires of practice across domains of experience (Gutiérrez & Rogoff, 2003; Lee, 2003; Nasir, 2000; Nasir et al., 2006). I contend that a belief in the inherent meanings of scientific images ignores the life experiences and prior knowledge that children bring to the science classroom and the interpretation of these images (Kress & van Leeuwen, 1996; Lemke, 1998; Roth, Pozzer-Ardenghi, & Han, 2005), thus continuing to marginalize a large number of children from fully connecting with school science (Warren et al., 2005). In order to highlight and privilege the boys' life experiences and prior knowledge with sound transmission, I focus on another principle of MRC, producing representations, in addition to a focus on their interpretation. I conceptualized the practice of representation as a co-constructed process between

the boys, their drawings, and the varied experiences with the scientific phenomenon.

The scientific focus of this study is the science of sound, specifically the transmission of sound. The study of sound transmission is a particularly interesting domain to explore because, although children live in a world filled with various sounds, little is known about children's understanding of this phenomenon (Houle & Barnett, 2008; Mazens & Lautrey, 2003). Previous studies have primarily focused on the difficulties that children have with understanding sound and their conceptualization of sound as a material substance (Chi, SLotta, & De Leeuw, 1994; Lautrey & Mazens, 2004). In this dissertation study, I look to further examine the notion that children conceptualize sound as a material substance and investigate if when placed in varied contexts, children also conceive of sound as a process involved in transmission. This inquiry derives from a previous pilot study (Wright, 2009) in which I explored 3rd graders' ideas regarding sound transmission and sound absorption. I observed children's emergent understandings of sound as the children provided explanations from an embodied imagining perspective (Ogonowski, 2008; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001). Embodied imagining, the act of imagining oneself within a scientific phenomenon (Ochs, Gonzales, & Jacoby, 1996), was utilized to engage the children with the phenomenon by explaining their ideas of sound transmission from the point of view of sound. The pilot study provided empirical evidence that children could possibly conceive of sound, and focus on the process aspects of sound, when provided with various contexts or

opportunities to explore the phenomenon. For example, throughout her explanation of sound reaching the audience, the case study student often described sound as "spreading" or "blowing" through the air, as opposed to previous literature that suggests that 3rd graders do not conceive of sound having to travel through a medium (Mazens & Lautrey, 2003). Building upon this initial exploration, the current study incorporated an examination of how African American boys' understandings are constructed within a group context and mediated through practices of representing and interpreting ideas through drawings.

Research Questions

Using the research problem and rationale to inform the purpose of this study, the central question driving this research is: *What are the intellectual and linguistic resources of African American boys in relation to the study and exploration of science?* From this central guiding question, I have further developed the following research questions that were specifically addressed in this study:

1. What intellectual and linguistic resources do a group of urban, 7th and 8th grade African American boys demonstrate while producing, interpreting, and critiquing invented representations of sound transmission?
2. What ideas, or aspects, of sound transmission do a group of urban, 7th and 8th grade African American boys collectively explore while

producing, interpreting, and critiquing invented representations of sound transmission?

3. What is the range of representational elements that a group of urban, 7th and 8th African American boys utilize while producing critiquing invented representations of ideas, or aspects, of sound transmission?

Goals of the Research

The primary goal of this research is to begin to expand the field's understanding of learning within science contexts and to also recognize the range of intellectual and linguistic resources that African American children, from various backgrounds and life experiences, bring to the discipline. Through this investigation, I look to highlight alternative theoretical and methodological approaches for working with children from communities of color. Such research is necessary given the continued positioning of African American boys as "at-risk" within education research and educational institutions (Ferguson, 2001; Swanson, Cunningham, & Spencer, 2003). Specifically, by taking a resources-rich view of learning (bang & Medin, 2010; Lee, 2001; Martin, 2006; Nasir, 2002; Rosebery, Ogonowski, DiSchino, & Warren, 2010) of these boys, this research looks to challenge the deficit-oriented thinking and methodologies that are often associated with them.

In addition, this research looks to explore and identify the varieties of resources that African American boys utilize in developing scientific understanding. For this study, this exploration focused on the ways of talking and

interpreting that a particular group of 7th and 8th grade African American boys brought to the tasks of producing, interpreting, and critiquing representations of sound transmission. Throughout this work, my goal has been to identify and elaborate the heterogenous ways of thinking within science, which inform generative opportunities for meaningful understanding of sound transmission. I argue that the use of the instructional approaches that reflect those described as the "pedagogy of poverty" (Haberman, 1991), need to be re-evaluated and debunked in order to provide alternative and rich opportunities for African American boys to display and use their intellectual and linguistic strengths in learning complex science.

CHAPTER 2:

LITERATURE REVIEW

In this chapter, I review literature relevant to exploring the intellectual and linguistic resources that African American boys bring to the study of the science of sound and the practice of representation. The chapter begins by specifically defining and examining the idea of sound transmission for the purposes of this dissertation. To inform my analysis of examining the boys' understanding of sound transmission, I analyze previous studies of children's understanding of sound transmission by situating them into either a discontinuous framework or a continuous framework. By doing so, I look to clearly position this dissertation study within a continuous framework and briefly discuss how other studies within this framework have informed this dissertation. To inform my analysis of the possible ways that the boys could represent sound transmission through drawings, I use the next section of this chapter to examine the heterogeneous ways that professional architects have approached the task of representing sound transmission. By highlighting the variation in these drawings, I look to identify possible approaches to examining the drawings produced by the boys within this study.

This section is followed by a review of the literature that highlights several intellectual and linguistic resources exhibited by boys from communities of color during their exploration of various science phenomena. This section includes a specific focus on the intellectual and linguistic resource of *Signifying,* a resource that I hypothesized would be instrumental in the boys' learning of complex

science ideas and developing understanding of scientific representations. This chapter concludes with an analysis of children's meta-representational competence, with a focus on the discussion of children's constructive resources during the production and interpretation of representations.

The Focus on Children's Conceptions of Sound Transmission

For the purposes of this study, sound is defined as a mechanical disturbance that propagates as a longitudinal wave through a given medium, such as a solid, liquid, or gas (Levine & Johnstone, 2000; Serway & Faughn, 1998). The origin of this disturbance is a vibrating object (e.g., a string on a guitar that has been plucked, a membrane of a drum that is struck, or column of air within a flute). During this process, individual particles of the medium are not transmitted, meaning that they are not actually "traveling" from the sound producer to the sound receiver. Instead, the particles fluctuate about an equilibrium position and simply transfer pressure changes by what is referred to as sound propagation (Parker, 2009). Scholars in science education (Houle & Barnett, 2008; Mazens & Lautrey, 2003) have argued that from a scientific perspective, children's discussions regarding sound transmission should focus on the sound's character as a process and not center on sound as a substantive entity that actually travels. Thus, the primary focus of previous misconceptions literature on children's ideas of sound has centered on researchers' beliefs in the necessity of correcting or fixing children's stable, but incorrect, conceptions of sound transmission. In the following subsection, I situate various studies regarding children's understanding

of sound transmission within either a discontinuous framework or continuous framework.

Elementary and middle school students' conceptions of sound transmission within the discontinuous and continuous traditions. Studies in the area of scientific sense making can generally be divided into two contrasting traditions of research: a discontinuous and continuous tradition (Hammer, 2000; Smith, diSessa, & Roschelle, 1993; Warren et al., 2001). Proponents of the discontinuous tradition, perhaps better known as the misconceptions traditions in science, hold that students' intuitive and experiential knowledge and ideas are "well-established and quite distinct from the conventional scientific views offered by instructors" (Slotta & Chi, 2006, p. 252). Literature regarding children's conceptions of sound has primarily been situated in the discontinuous tradition with a specific focus on children's difficulties understanding the phenomenon because they conceive of sound as a material substance (Driver, Squires, Rushworth, & Wood-Robinson, 1994; Mazens & Lautrey, 2003). From the literature that is available, sound has often been described as a difficult concept for both elementary school-aged children (Barman, Barman, & Miller, 1996; Gustafson, 1991; Mazens & Lautrey, 2003) and college students (Linder, 1991; Wittman, Steinberg, & Redish, 2003) to understand. For example, Driver et al. (1994) claim that children tend to think that sounds need an unobstructed route in order to travel from a sound producer to a sound receiver; at the same time, children were found to rarely mention the role of the medium in this process.

Additionally, children's conceptualizations of sound as a substance have been, at times, attributed to their omission of recognizing the necessity of a medium in the process. For example, early elementary school children are said to think that sounds move in distinct directions and with a given purpose.

Other studies within the discontinuous tradition have viewed children's conceptions of sound transmission as primarily a developmental issue. Mazens and Lautrey (2003) found that children from ages 6-10 years old attributed several physical properties to sound, including: substantiality, trajectory, permanence, and weight. Although these researchers found that these physical properties were applied less and less as children's ages increased, the property of substantiality seemed to remain longer than any of the other properties. The property of substantiality assumes that sound is made of matter and cannot pass through solids. With strong beliefs of the substantiality of sound, children were found to believe that sound could only pass through solids if the sound was stronger or harder. In addition, sound was often conceived as being transparent, invisible, and being different in nature than other objects (i.e., conceiving of sound as having "air-like" or "ghost-like" qualities). In the same study, researchers also found that children closer to the age of six represented sound as traveling in straight lines, while also traveling only to people (see "a" in Figure 1). They also concluded that children's conceptions of sound transmission changed around the time they reached the age of ten, when children began to represent sound as traveling in all

directions (see "b" in Figure 1)[4]. Additionally, Mazens and Lautrey (2003) maintained the belief that the variation in children's beliefs and explanations all derived from the same mental model, one of sound as a material substance, thus arguing that children possessed stable beliefs and theories concerning sound transmission.

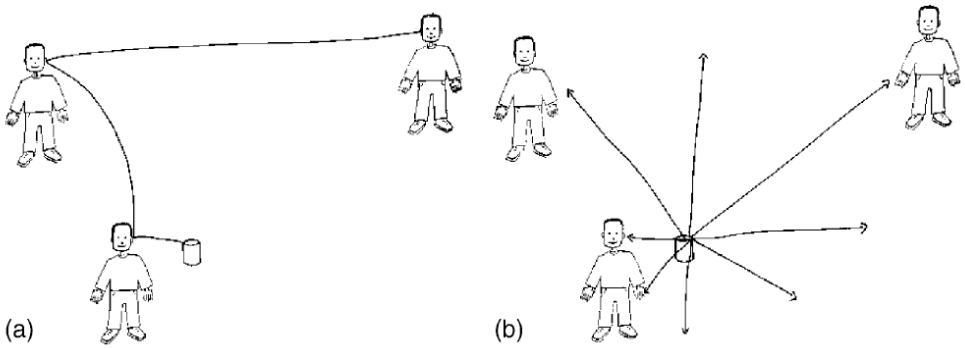

Figure 1. Researchers' drawings showing sound going only to people (a) and in all directions (b) (Mazens & Lautrey, 2003, p. 168).

Continuing within the discontinuous tradition, 5th graders were found to view sound waves as transverse waves that travel like water and light (Barman, Barman et al. (1991). Additionally, children discussed sound as moving by bouncing off of different things. For example, one child explains, "It [sound] bounces off things, like the wall or table, and gets to me (p. 65)." Again, in this study, the researchers viewed children's beliefs of sound transmission as stable misconceptions that need to be repaired or fixed and that could be altered by an appropriate curriculum. Within the discontinuous tradition, science instruction

[4] The researchers of the study generated the drawings in Figure 1 in order to illustrate their findings regarding children's conceptions of sound transmission. Unfortunately, the drawings produced by the actual children were not included in their publication.

and curricula are strongly encouraged to account for patterns of student misconceptions, with the goal of replacing, repairing, and fixing students' wrong ideas and ways of knowing. Some researchers (Barman et al., 1996; Mazens & Lautrey, 2003) feel that it is the goal of instruction and/or curricula to specifically dispel those ideas that are believed to be children's misconceptions (e.g., children's belief that sounds can be produced without using any material objects or that sounds cannot travel through liquids and solids). From a historical perspective that highlights the educational experiences of boys from communities of color, the view of student sense making put forward by the discontinuous tradition is ominously reminiscent of that put forward by the cultural deficit theory[5] (Ladson-Billings, 1995) and the positioning of these boys as "at-risk" (Lee, 2003; Noguera, 2003). Again, I contend, with others (Brown, 2006; Zacharia & Barton, 2004), that classroom cultures often marginalize children from communities of color partly due to a failure to recognize children's everyday, community, and/or family-based knowledge, linguistic practices, and ways of thinking.

[5] While I recognize that the cultural deficit theory was purportedly, or explicitly, introduced to explain the educational difficulties of all children from working-class communities. I maintain that the underlying, or implicit, emphasis was on the children from communities of color. Many scholars have traced the history of this orientation (Banks, 1993; Ladson-Billings, 2006; Solórzano, 1997; Tate, 1997). First, they point out that in 1996, the approximate time of the theory's widespread acceptance, 65% of African America children were living below the poverty line, while 29% of Caucasian children were in a similar situation (U.S. Census Bureau, 2007). Second, they saw how the widespread acceptance and application of the cultural deficit theory directly followed the belief in the genetic deficit theory (Banks, 1993), which maintained that individuals from communities of color were genetically intellectually inferior to their European and European American counterparts.

In contrast, a second tradition of research exists that views students' sense making and that of science as continuous with one another (Hammer, 2000; Smith et al., 1993; Warren et al., 2001). The continuous tradition,

> focuses on understanding the productive conceptual, meta-representational, linguistic, experiential, and epistemological resources students have for advancing their understanding of scientific views. (Warren et al., 2001, p. 531)

This perspective on science education research takes as a basic tenet that scholars examine the varying intra- and inter-group intellectual and linguistic resources that children bring to science exploration and investigate ways of building upon these understandings and practices. Working within this tradition of research, Eshach and Schwartz (2006) found that 8th graders described sound as traveling in straight lines, spiral lines (see Figure 2), crescent-shaped lines (see Figure 3 and Figure 4), or lines with the same qualities as water. This study was of particular interest to me because it was one of the few studies that did not adhere to the misconceptions tradition of children's ideas concerning sound transmission. Additionally, this study informed my methodological approach of utilizing children's drawings as an alternate mode of representation in exploring their ideas regarding sound transmission. By displaying the heterogeneity in children's drawings and ideas regarding sound transmission, Eshach and Schwartz (2006) actually served as an important resource for the study described in this dissertation.

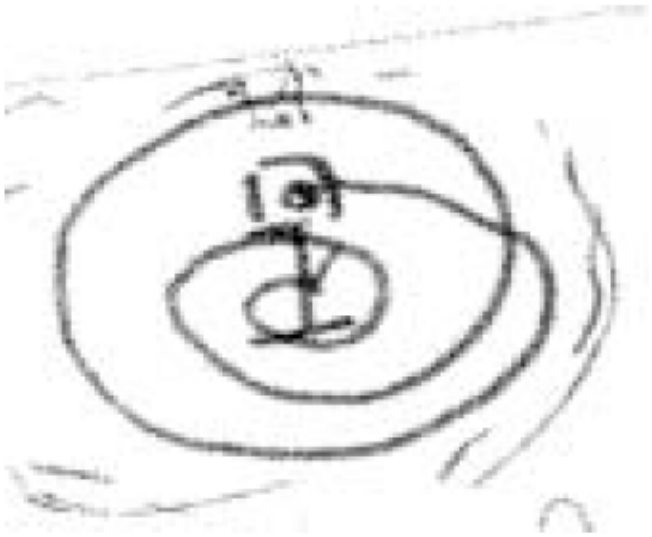

Figure 2. Drawing of an 8th grader representing sound transmission with spiral lines (Eshach & Schwartz, 2006, p. 752).

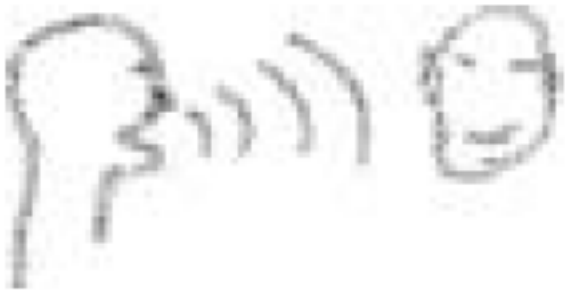

Figure 3. Drawing of an 8th grader representing sound transmission with crescent-shaped lines (Eshach & Schwartz, 2006, p. 749).

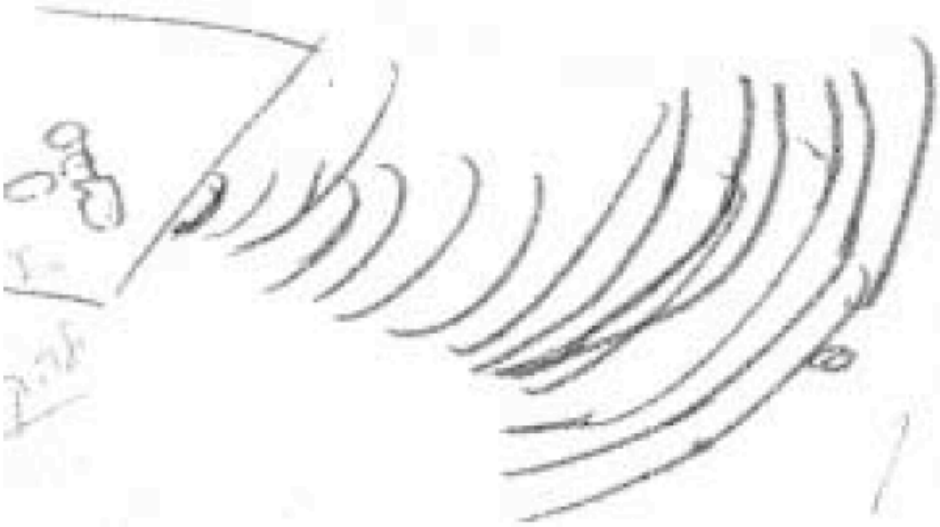

Figure 4. Drawing of an 8th grader representing sound transmission with cresecnt-shaped lines (Eshach & Schwartz, 2006, p. 746).

Other studies reported that middle school and secondary school children were found to explain the process of sound transmission by saying that sound is pushed by air as it leaves a noisemaker (e.g., a person's mouth or musical instrument) or traveling in the form of air (Driver et al., 1994; Eshach & Schwartz, 2006). Again, this finding prompts more questions about children's ideas regarding sound transmission. If provided with an alternate context or if the questions were framed differently, would these children have conceived of sound as traveling in the form of air? What would have been a child's response if the question were framed around sound traveling through a solid or a liquid? Alternative questions such as these informed my previous pilot study (Wright, 2009). I found that when allowed to think about sound from an embodied imagining perspective (Keller, 1993; Ochs et al., 1996), one female 3rd grade

student described herself as "spreading through the air." In this instance, she described herself as traveling *through* the air versus being pushed by the air or traveling in the form of air. In addition, she explicitly recognized air as the medium for her transmission. Findings such as these provide the foundation for my examination of children's ideas of sound transmission within different contexts, as well as not conceiving their ideas as monolithic misconceptions. Researchers utilizing this framework (Gustafson, 1991) have described the variation in 4th graders' explanations regarding sound transmission as deriving from a complex web of ideas, in which children continuously consider and modify their understandings of the phenomena. In order to gain insight into children's understanding of scientific ideas and this complex web of ideas, researchers such as Treagust, Jacobwitz, Gallagher, and Parker (2001) argued for the use of "drawings, diagrams, and models constructed by students in conjunction with oral or written descriptions or explanations" (p. 139). Thus, the study reported in this dissertation used children's drawings and discourse on and about those drawings as a model of examining the children's understandings of sound transmission.

Heterogeneous ways of "seeing" sound in architectural design

Architects often engage in the practice of producing representations to be utilized on various site analyses. The primary role of such analysis is to provide information about the site before starting any conceptual designs of the building or space (White, 2004). The drawings produced are not only for communication,

but also to help architects see and understand the contexts that they are working within. Typical site issues addressed through these representations include site location, drainage patterns, traffic patterns, views to and from the site, and existing structures. Hypothetical site issues that include the significant noise, or sounds, on and around a hypothetical site is the focus of this section including how sound is represented in subsequent drawings.

For an architect representing sound on a site map (see Figure 5 and Figure 6), the following kinds of information typically become the focus: 1) the location of the noise or the sound, 2) the source or generator of the noise, 3) the schedule or duration of the noise, 4) the type of noise, and 5) the intensity of the noise (White, 2004). As seen in Figure 5 and Figure 6, representing sound transmission can take on various forms and utilize varying symbols, depending upon the aspects of sound that one is attempting to focus on and highlight through drawing.

Figure 5 is an example of a site analysis of sound transmission on and around a hypothetical building site. The notations used within this site analysis can inform the reader about what elements of sound transmission the architect is attempting to emphasize. For example, the architect's use of different line weights[6] and width of the symbols is meant to contrasts the varying intensities among the different sounds. Wider notations and thicker line weights represent a louder sound impacting the building site. In addition to the intensity of the sound,

[6] In drawing, line weight is a term used to describe the strength, heaviness, or darkness of a line (White, 2004). Typically, this is accomplished by varying the pressure applied to the drawing instrument (i.e., pencil, pen, or marker) or by altering the angle of the drawing instrument's contact with the paper or drawing area.

the architect emphasized the direction of the sound transmission through the use of the arrows.

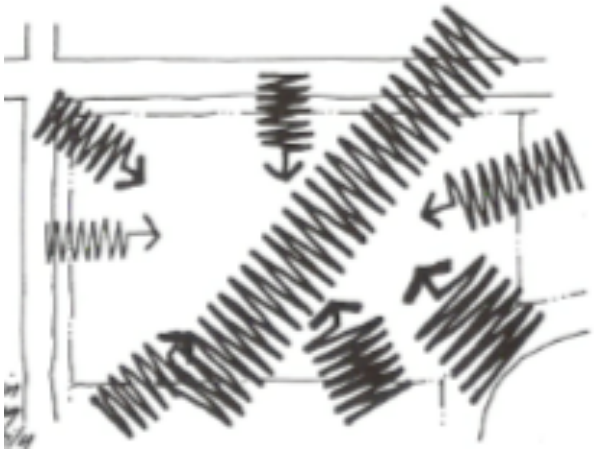

Figure 5. Example of an architectural site analysis representing sound transmission data (White, 2004, p. 98).

Figure 6 is another example of a site analysis of sound transmission on and around a hypothetical building site. This example was selected because it utilized the same building site as represented in Figure 5, but emphasized different aspects of sound transmission. The architect's use of text and different notations to depict the source of the sound emphasized the source of sound transmission as primary focus. For example, the circles (see Figure 6) represent a source of sound from a point source on the map (e.g., a children's playground or a construction site), as opposed to a continuous source of noise as represented by the linear source (see Figure 6; e.g., cars traveling along a busy street or airplanes traveling above the site). The architect's focus on sound transmission can be represented through the selection and placement of notations within the architectural site analyses. The architects' use of notations to emphasize various,

and specific, aspects of sound transmission was used as a model for the analysis of children's drawings utilized in the study reported in this dissertation. For example, I could begin my analysis of the boys' drawings to determine if they also focused on similar aspects of sound transmission, including: 1) location of the sound, 2) the source of the sound, 3) the duration of the sound, 4) the type of sound, and 5) the intensity of the sound (White, 2004). In addition, I take notice of the notations that the architects utilize, as well as how they are utilized. Figure 5 utilized one notation, but included line weight, width of the notation, and arrowheads to highlight specific aspects of sound transmission. Figure 6 utilized three different notations, while also incorporating the element of the width of the notations. These elements can serve as a foundation for beginning the analysis of the boys' drawings within this study.

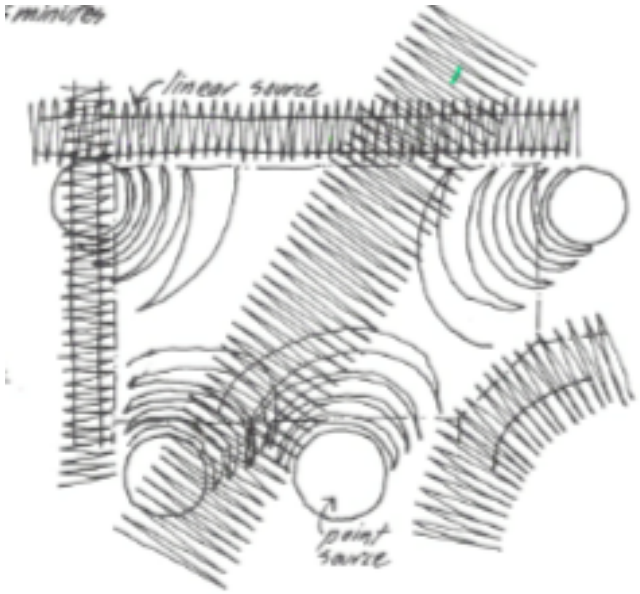

Figure 6. Example of an architectural site analysis representing sound transmission data (White, 2004, p. 98).

Investigating the Intellectual and Linguistic Resources Demonstrated by Boys from Communities of Color

Although growing, literature focusing on the intellectual and linguistic resources that boys from communities of color bring to the discipline of science is limited. This scarcity of literature could be indicative of the often utilized deficit-oriented theoretical and methodological approaches often connected with these boys, thus furthering the importance of the current research. In this section, I briefly review the central findings of several studies in order to highlight what the field currently knows about the resources that boys from communities bring to the science classroom. I argue that many of the intellectual and linguistic resources exhibited by boys from communities of color are often not recognized in school science, and are a major contributor to these students' documented continued under-performance and marginalization (Warren et al., 2001; Warren, Bang, Wright, Rosebery, Hudicourt-Barnes, & Nemirovsky, 2008; Warren & Rosebery, 2011). In highlighting the scientific value of various intellectual and linguistic resources, I look to broaden our understanding of what it means to be "scientific" and to provide evidence for the possible use of these resources within our classrooms.

Previous studies have highlighted boys' use of the intellectual resource embodied imagining (Ogonowski, 2008; Ochs et al., 1996). For example, Warren et al. (2001) examined how a Latino, elementary school-aged boy approached the problem of designing an experiment that explored ants' preferences for darkness or light. Through the intellectual practice of embodied imagining, the use of

which has been documented within various scientific communities (Keller, 1983; Ochs et al., 1996; Whitrow, 1972; Wolpert & Richards, 1977), the boy explored the behavioral ecology of ants by imagining himself as an ant. Using two small, shoebox-like spaces, the boy's work group decided to use dirt in one of the boxes to create a condition of darkness and the omission of dirt in the other to create a condition of non-darkness. Imagining himself as an ant, the boy determined that including dirt in their design of an experiment would not be valid because he hypothesized that the ants may choose the dirt, not because of its darkness, but "maybe to keep warm..." (p. 543). In this instance, the boy attempted to create a situation where only the variable of darkness or non-darkness could be examined. Thus, by imagining himself as an ant and the "feeling of warmth" that an ant may encounter, the boy helped his group design an experiment that effectively investigated their question regarding ants' preferences for darkness.

In a similar study, eight African American high school-aged boys utilized their experiential knowledge during a yearlong science lunch group (Seiler, 2001). During a discussion regarding how sounds produce high and low pitches, one participant said:

> It's the same way at my job, right? When I'm cutting hair, if the clippers don't sound a certain way, I take a screwdriver ad twist the screw in the side. Somethin' getting loose. So, if it gets low and slower or increase the sound and become faster. (p. 1008)

This excerpt illustrates the youth's use of his experiential knowledge with the scientific phenomenon of pitch, as well as his use of a narrative as a linguistic resource (Gee & Clinton, 2000; Michaels & Sohmer, 2000) to explain the connections he saw. Seiler's (2000) study highlighted the importance of providing a space for these boys to participate in science activities and discussions from their perspective. The boys were given the opportunity to explore and debate the "scientific ideas" that they deemed as important to them and their community. For this dissertation study, I look forward to identifying the aspects of sound transmission that the group of middle school boys I worked with deem as necessary to explore in regards to sound transmission.

Previous research (Warren et al., 2001) has also challenged researchers to closely examine how children are using their community and/or home-based linguistic practices and not to assume that the content of the students' explanations or their discursive practices lack intellectual substance or fall outside of what should be considered "scientific" because they take forms other than those officially recognized in school, i.e., "academic language." In the remainder of this chapter, I will utilize the fundamental principles of the continuous tradition and the findings of studies reviewed here to develop a case for examining *Signifying,* a linguistic practice with a rich and historic tradition in the African American community, as a linguistic resource for learning science amongst a group of middle school African American boys.

Signifying as a linguistic resource for learning. The intellectual and linguistic practices of children from communities of color are often viewed as disconnected from, or contradicting the practices valued in school (Ferguson, 2001; Lynn et al., 2010). Heath (1987) recognized this more than twenty years ago:

> The school has seemed unable to recognize and take up the potentially positive interactive and adaptive and interpretive habits learned by Black American children (as well as other nonmainstream groups), rural and urban, within their families and on the streets. The uses of language - spoken and written - are wide ranging, and many represent skills that would benefit all youngsters; keen listening and observational skills, quick recognition of nuanced roles, rapid-fire dialogue, hard-driving argumentation, succinct recapitulation of an event, striking metaphors, and comparative analyses based on unexpected analogies. (p. 370)

Signifying is one of the linguistic practices to which Heath (1987) is referring. *Signifying* is described as a "form of social discourse in African American community" (Lee, 2000, p. 191), where encoded messages regularly embody implicit content or function (Mitchell-Kernan, 1977). The meanings described here are often filled with elements of indirection, humor, irony, wit, and an ability to play on words (Gates, 1989; Smitherman, 1977). Scholars, writers, and

historians, alike, have examined *Signifying* as a cultural linguistic practice that requires many of the oral and intellectual skills earlier described by Heath (1987). Furthermore, like all language practices, *Signifying* is a dynamic and creative act that is continuously constructed by its users. Lee (2000) points out that *Signifying* is constantly changing and may be referred to by "different names in different communities or historical periods, and certain skills may be more dominant within one gender" (p. 198) than another. Within African American communities in various regions of the United States, *Signifying* may also be classified or referred to as "marking," "loud-talking," "specifying," "testifying," "calling out (of one's name)," "sounding," "rapping," (Gates, 1984) "joning," and "cracking (jokes)" (Lee, 1995). Gates (2010) further highlighted the important stature that this linguistic practice has within the fabric of African American culture and communities:

> *Signifying* is a defining rhetorical principle of all African American discourse, the language game of black games, both sacred and secular, from the preacher's call-and-response to the irony and indirection of playing the Dozens[7]. These oral poets practiced their arts in ritual settings such as the street corner or the barbershop, sometimes engaging in verbal duels with contenders like a linguistic boxing match. These recitations were a form of artistic practices and honing, but were also the source of great

[7] "The Dozens" is an element of African American oral tradition where, typically, two competitors engage in a competition of good-natured insults or trash talking (Lee, 2000). The Dozens is a culturally approved method of talking about somebody, while at the same time, participants are expected not to take any of the humor to heart (Smitherman, 1977).

> entertainment, displayed before an audience with a most sophisticated ear. (p. xxiii)

Gates' insights into the practice of *Signifying* clearly illustrate how it is intertwined with and helps construct routine, daily experiences within the African American community. In addition, Gates' description highlights the performative aspect of *Signifying* that is integrated with this community's ways with words (Spears, 2007). Thus, *Signifying* is not only identified by one's use of metaphors, irony, or wit, but also includes "the stylistic dramatization of the self that individuals infuse into their behaviors" (Spears, 2007, p. 228). Unfortunately, the ways in which many young men within the African American community engage in conversation (i.e., aggressive argumentation, sarcasm, and wit) have been viewed as inappropriate forms of attention grabbing by members of other ethnic groups. Scholars have argued that this verbal art form, as described by Smitherman (1977) and Spears (2007), is a shared communal attitude or stance towards language use that also serves as a means of cultural self-definition (Lee, 2000; Mitchell-Kernan, 1977). From this perspective, *Signifying* and other key elements of African American talk, such as vigorous argumentation and metaphorical inventions, are central to African American children's sense making; unfortunately, they are not always valued in school (Brown, 2006; Heath, 1987). In this dissertation, I will present data that illustrates that these communicative practices are indeed intricate and require a mastery of language and context, and have clear and identifiable connections to school science.

Because acts of *Signifying* routinely include messages that are communicated through innuendo and double meaning, speakers are required to possess a high degree of communicative competence with this practice. This competence, in turn, enables practioners to quickly process these multiple meanings in light of knowledge of the possible purposes of others involved in the exchange (Lee, 1995).

Geneva Smitherman conducted original, groundbreaking linguistic analyses of African American language practices (1977, 1999). She identified that the following features are characteristics of *Signifying* (Smitherman, 1977):

> Exaggerated language (unusual words, high talk); mimicry; proverbial statements and aphoristic phrasing; punning and play on words; spontaneity and improvisation; image-making and metaphor; braggadocio; indirection (circumlocution, suggestiveness); and tonal semantics. (p. 94)

As noted earlier, recognizing acts of *Signifying* requires a complex linguistic competence that takes years of apprenticeship and practice. It can be difficult for those who are unfamiliar with it to identify and value its complexity, despite Smitherman's (1977) description of explicit characteristics. As will be detailed in the following subsections, there is great variation among acts of *Signifying:* a relatively simple *Signifying* act may incorporate only one or two characteristics, while a more elaborate act may simultaneously incorporate multiple characteristics. Thus, the possible combinations of these characteristics are

infinite and make the use and recognition of these acts very complex for those who are unfamiliar with the acts of Signifying. In order to ground this idea of *Signifying,* I will highlight and specifically discuss three characteristics of *Signifying* from current research: the use of indirection/innuendo, braggadocio, and sarcasm/irony. These characteristics are featured because they are the primary characteristics that the boys in my study use in developing a shared understanding of sound transmission and of the ways of representing the phenomenon.

Indirection/Innuendo. A defining characteristic of *Signifying* is one's use of indirection, i.e., allusive remarks or suggestive hints, in order to communicate meaning. To ground the idea of indirection, I will analyze an example provided by Smitherman (1977), from the opening of a speech given by Malcolm X in 1964:

> Mr. Moderator, Brother Lomax, brothers and sisters, friends and enemies; I just can't believe that everyone here is a friend and I don't want to leave anybody out. (p. 97-98)

A surface-meaning interpretation of Malcolm's statement is that he is merely being courteous and acknowledging all members of the audience, including those who may disagree with his message. Contrary to this described "dictionary" interpretation, a listener skilled in the art of *Signifying* recognizes several characteristics that signal that Malcolm is sending an indirect message, or criticism, to those audience members whom he classified as "enemies." First,

Malcolm's acknowledgement and juxtaposition of "enemies" in the same utterance as his acknowledgement of his "brothers and sisters" is a clear indicator of his engagement in an act of *Signifying.* Malcolm's use of "brothers and sisters" was not an acknowledgement of his "blood" siblings, but an acknowledgement of the African American men and women in the audience who shared common purposes and values of equality during the Civil Rights period. Second, although speaking to an overwhelmingly majority Black audience, all of whom should presumably be "friends" or "brothers or sisters," Malcolm used the term "enemies" to indirectly call out members of the audience who he believed were present to spy on his speech. Specifically, he ingeniously points to a historical pattern of Black people acting as traitors who run and report what they have learned to White people in authority (Smitherman, 1977). The term "Black Judases" became popular within African American culture to describe these individuals; it derives from the time when slave uprisings were defeated based on the betrayal of slaves by other slaves.

So, in his opening statement, Malcolm is implicitly acknowledging the probability that "Black Judases" are present within the audience, and simultaneously announcing that despite the expected betrayal that he will not adjust the content of his sermon. In addition, not only does Malcolm acknowledge the presence of "Black Judases," but he also makes certain that they are aware that he considered them to be "enemies." Finally, as I have tried to make clear from this analysis, Malcolm's use of indirectness illustrated his awareness that his audience shared very specific historical and cultural knowledge that they will use,

along with knowledge of current contextual factors (i.e., the politics of the 1960's), to decipher the underlying meaning of his speech.

When using indirection, the speaker alludes to and implies meanings that are rarely made explicit to the listener(s). Indirection is so central to *Signifying* that a speech act is typically not considered to be *Signifying* unless it is present (Mitchell-Kernan, 1999). The use of indirection requires the listener(s) to quickly analyze a field of possible meanings and decipher the speaker's intent. That is, the apparent significance, or the surface meaning, of the speaker's message differs from its actual significance or meaning. Thus, the intent of the speech act cannot be determined by simply considering the "surface level" meaning of the words contained in an utterance (Mitchell-Kernan, 1999; Smitherman, 1977). The inclusion of indirection within a communicative exchange requires a level of shared cultural knowledge between the speaker and listener in order to produce the intended semantic interpretation. This complex linguistic skill was an integral component in the boys' exploration of sound transmission and the ways of representing sound transmission, as it became a way for the boys to engage in group critiques of their ideas regarding sound transmission and their drawings that represented sound transmission. Thus, indirection/innuendo became a vehicle for further examining the complexities regarding the science and representation of sound transmission.

Braggadocio. Another characteristic of *Signifying* is the inclusion of braggadocio, where the *Signifier* engages in bragging or boastful behavior or

language. Muhammad Ali was one of the most famous individuals to master and publicly use braggadocio. For example in describing his physical ability to quickly maneuver around the boxing ring, Ali stated the following to a group of reporters:

> I am the astronaut of boxing. Joe Louis and [Jack] Dempsey were just pilots. I'm in a world of my own.

In this example, Muhammad uses several elements of *Signifying* (i.e., image-making and metaphorical language, indirection, and braggadocio), but braggadocio is the most prominent element and focus of this section. In creating a response to a reporter who compared Ali to previous boxing champions, Joe Louis and Jack Dempsey, Muhammad incorporated elements of braggadocio to playfully set his boxing abilities apart from and above theirs. Ali is clearly not claiming to be an astronaut, or suggesting that Louis and Dempsey are actually pilots. Instead, he is referring to the fact that astronauts "fly higher" or reach "higher altitudes" than pilots in order to proclaim his dominance in boxing. Throughout his boxing career, Muhammad Ali utilized braggadocio and other elements of *Signifying* to not only establish and maintain his status as the premier boxer of his day, but to display his prodigious intellectual and linguistic abilities.

Typical topics of braggadocio often include "physical prowess, fighting abilities, lovesmanship, or coolness" (Smitherman, 1977, p. 97). Generally, the aim of a speech act containing braggadocio is to playfully convey the perception that the *Signifier* is capable of achieving the impossible, or creating the image of

an "omnipotent, fearless being" (Smitherman, 1977, p. 97). Again, I found braggadocio as a characteristic frequently utilized by the participants in this dissertation study. I found that it was used most in times in which the boys were organizing an argument and used braggadocio as a method for introducing and validating their evidence. The practice of justifying and validating findings is a requirement in the practice of scientific argumentation (Hudicourt-Barnes, 2003), and the participants in this dissertation used their community-based linguistic skills and practices to engage in the practice of argumentation.

Sarcasm/Irony. The use of sarcasm is another key and intriguing characteristic of *Signifying* (Lee, 1995). To further elaborate on sarcasm's unique role in *Signifying,* I will discuss an example provided by Mitchell-Kernan (1977). Prior to this example, Grace, who has four children, has previously announced that she is not going to have any more babies. Sometime later, upon discovering that she is pregnant with child number five, she has decided not to share the news with anyone. On the day of this example, her pregnancy has started to show. Rochelle, Grace's sister, arrives at Grace's home and the following exchange ensues:

> Rochelle: Girl, you sure need to join the Metrecal for lunch bunch.
>
> Grace: [Non-committal] Yea, I guess I am putting on weight.
>
> Rochelle: Now look here, girl, we both standing here soaking wet and you still trying to tell me it ain't raining. (p. 318-319)

Several aspects of this exchange illustrate the use of sarcasm / irony. First, Rochelle uses a reference to Metrecal, a popular brand of diet food at the time, to initially bring attention to the obvious weight that Grace has gained. Rochelle, who by this time is very aware of Grace's pregnancy, uses sarcasm to indirectly or ironically ask Grace, "How stupid do you think I am?" Still not willing to divulge her secret, however, Grace continues with the "game" of hiding her pregnancy and acknowledges that she is "putting on a little weight." Grace's response prompts another sarcastic comment, and one that also includes the element of indirection, from Rochelle, "Now look here, girl, we both standing here soaking wet and you still trying to tell me it ain't raining" should not be interpreted literally; the two sisters are not soaking wet or standing in pouring rain. Using elements of ironic sarcasm, Rochelle's response makes it clear that Grace is attempting to convince Rochelle of a reality that is utterly false. Although some listeners may construe Rochelle's message as mildly insulting, Grace found the exchange highly amusing (Mitchell-Kernan, 1977). She was thoroughly impressed by Rochelle's humorous and clever use of wit and words to inform her that she knew she was pregnant, thus again highlighting the status that this linguistic skill has within many African American communities.

Summary. By reviewing the literature regarding the intellectual and linguistic resources that boys from communities of color bring to the science classroom (Seiler, 2001; Warren et al., 2001), I have specifically situated this study within a continuous tradition of science education research. Again, this

tradition proposes that scholars develop theoretical and methodological approaches that recognize and value children's resources as possible connections for learning science. In addition, this section also highlighted the practice of *Signifying* within the African American community, as well as specifically examining three of its elements: indirection/innuendo, braggadocio, and sarcasm/irony. The study described in this dissertation focuses on a group of 7th and 8th grade, African American boys' use of *Signifying* as they explore the science of sound through the production and interpretation of their drawings. I specifically aim to connect the boys' intellectual and linguistic practices within their group engagement with the scientific content, thus arguing for the recognition of *Signifying* as a legitimate resource for constructing understanding within the science classroom.

Exploring Meta-Representational Competence

Studies in meta-representational competence (MRC) share the common interest of exploring the comprehensive range of competencies that students bring to the tasks of producing and using external representations (diSessa, 2004; diSessa & Sherin, 2000). This range of competencies has an integral role in students' abilities to select, produce, use, critique, and modify representations. MRC studies are deeply rooted in the premise that students' intuitive ideas serve as a foundation for developing a deeper understanding of the practice of representation, as well as the concept being represented. Thus, I view MRC as congruous with the sense making approach (Warren et al., 2001; Warren et al.,

2005) utilized in the current study. By building upon previous work in MRC, I look to emphasize the role of culture in the teaching and learning of representations, specifically the representation of the scientific phenomenon of sound. Specifically, I focus the analysis of the study reported in this dissertation on the impact of a group's cultural and social interactions on group members' developing representational competencies (Enyedy, 2005). I believe that this focus will contribute to the previous studies within MRC by exploring the interplay between cultural processes in cognition (Nasir, 2000; Saxe, 2005).

Previous work in MRC has looked beyond what has been considered student "misconceptions" of producing and interpreting external representations and privileges that students' ways of knowing, thinking, and conceptualizing as precursors to deeper representational and scientific understanding. For example, the misconceptions literature regarding representations has primarily focused on students' mistakes or inabilities in producing and interpreting a small subset of representations, including graphs and tables (Leinhardt, Zaslavsky, & Stein, 1990). In contrast, diSesaa et al (1991) argued that through a process of iterative design that included interactions and critiques with peers, a group of 6th graders produced representations of motion that resembled conventional graphs of speed versus time. Although these students had not received any direct or formal instruction in designing representations and had not previously produced conventional representations of graphs, this particular group of students drew on their intuitive understandings while refining their representations through the process of production and interpretation. My contribution to such a line of inquiry

would be to specifically focus how a group of 7th and 8th grade African American boys' interpretation and critiques impact individual children's and the overall group's competency with representing sound transmission, as well as focusing on the group's methods of engaging each other, their drawings, and the phenomenon of sound. I believe that examining and understanding how the group functioned in the process of developing representational competencies would be a valuable resource when thinking of designing and implementing learning spaces where all children are able to engage in representational practices and the studied scientific concept. Other studies have also explored students' MRC in regards to various scientific phenomena, including the representation of height in two-dimensional maps (Enyedy, 2005), the representation model and real landscapes (Azevedo, 2000), and further explorations into the concept of motion (Sherin, 2000). The central findings from these studies, including diSessa et al. (1991), have identified how children's constructive and critical resources have contributed to their overall competency in the practice of representation. Of these two types of resources, constructive resources were identified as contributing the most to this dissertation study. Constructive resources are the competencies that contribute specifically to children's ability to "invent" representations (Sherin, 2000). Particularly, these resources include children's intuitive ideas and practices for producing representations that have the potential to develop into a new understanding of the practice of representation, as well as the scientific idea being represented. The remaining sections regarding MRC will specifically focus on how this dissertation study builds upon previous findings regarding children constructive resources.

Constructive resources. Constructive resources have been conceptualized as the ideas and skills that children posses that inform their abilities for inventing and designing new representations (diSessa, 2004). MRC posits that this collection of ideas is what children upon during their process of producing representations (Sherin, 2000), thus, the MRC perspective holds a view that the children's resources are "continuous" with those in science. Despite the primary belief that these resources are continuous with practices in science, studies in MRC have also explored how the existence of these resources may hinder the process of learning conventional, or standard, scientific forms (Azevedo, 2000; diSessa, 2004; Sherin, 2000). Thus, understanding that representations can function differently within different contexts is recognized as another goal for children as they explore their meta-representational competence. This suggests the importance of the identification of constructive resources in children's representations in order to explore their continuities with scientific representations, as well as how these resources could pose difficulties in the learning of specific representations. Utilizing literature specifically focused on the production of MRC, the following section will highlight several constructive resources that I deemed relevant to the current dissertation research because they appeared during the analysis of the children's drawings: *a) drawing, b) temporal sequencing,* and *c) line segments.*

Drawing. Children's knowledge and awareness of the practices associated with drawing was identified as a constructive resource, within explorations of both motion and terrain (Azevedo, 2000; Sherin, 2000). In these studies, drawing was defined as a set of conventions and techniques that children utilize for depicting various aspects of the world on paper. Both Azevedo (2000) and Sherin (2000) identified children's familiarity with drawing, as developed within Western culture, as the initial constructive resource. Although children's awareness and abilities in drawing were identified as being continuous with the development of scientific representations, these studies also explored how children's knowledge could be viewed as a hinderance. For example, Sherin (2000) identified how children's idea of "space=space" in drawings could also serve as a limitation when representing the idea of motion. This possible limitation can be further examined using the drawing in Figure 7. Figure 7 is an illustration that was used by a 9th grader to illustrate a car's reduction in speed as it traveled from left to right. In specifically highlighting the notion of "space=space," I focus on the relationship between the series of cars and the series of cacti "below" the cars. In this instance, the cacti were included to represent their existence on the "side of the road." Within the idea of students' "space=space" notion, the cacti are drawn "below" the cars, so the cacti must actually be below the cars in "real life." Thus, children's knowledge of drawing served as both a continuous resource, as well as a limitation, for producing scientific representations of motion. The resource being children's knowledge and abilities of drawing, and the limitation being how students may relate the scenario

in a drawing to what is actually happening in real life. Since the use of drawing is a major element in the the reported dissertation study, I expect the participants' understanding of drawings to be a major element of my analysis into their understanding and developing understanding of sound transmission.

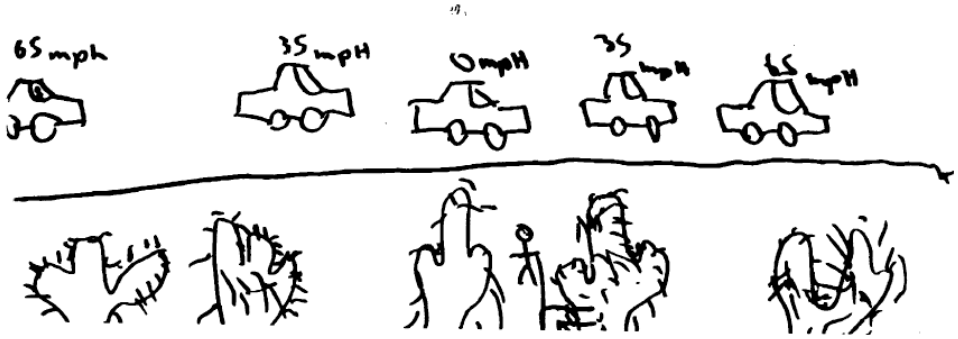

Figure 7. Example drawing from a 9th grader depicting motion (Sherin, 2000, p. 412).

Temporal Sequencing. During explorations that involve representing motion, temporal sequencing was identified as another constructive resource (Sherin, 2000). Temporal sequencing is described as a linear sequence of distinct drawing elements that depict what happens during a motion, one step at a time. The elements within this sequence are often conceived as if the student was utilizing a series of symbols or notations to recite a story regarding motion. For example, Figure 8 "recites" the story of a moving vehicle, when it is "read" from left to right. Initially, the 9th grader depicted the motion of the vehicle at a high speed, as represented by the longer vertical lines on the left side of the first large circle (see Figure 8). Next, the vehicle continues to move at a constant speed, as depicted by the consistent height of the first 14 vertical lines, and stops for a long

period of time, as represented by the larger solid circle. After the initial stop, the speed of the vehicle gradually increases from a slower to an increased speed, as represented by the gradual increase in the length of the vertical lines. Next, the vehicle stops for a shorter period of time, as depicted by the smaller solid circle. Finally, the speed of the vehicle, again, gradually increases, as depicted by the increasing length of the final set of vertical lines.

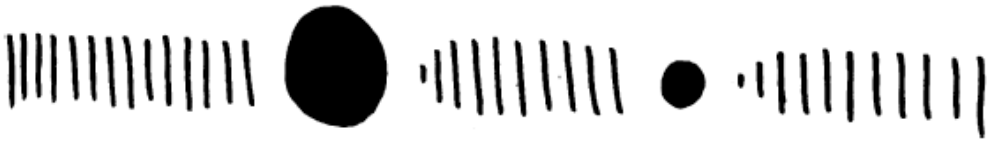

Figure 8. Example of temporal sequencing completed by a 9th grader (Sherin, 2000, p. 426).

Again, temporal sequencing is identified as a constructive resource with possible continuities with scientific practice, but possible limitations may also exist. Sherin (2000) highlights the linear aspect (i.e., interpreting the representation in a sequence from left to right) of the resource as having the possibility of posing problems when students are faced with the necessity of designing representations that can be expressed through a linear depiction. Understanding that children often view sound as a material substance (Mazens & Lautrey, 2003) that travels from the sound producer to the sound receiver, I believe the resource of temporal sequencing may be important in how the participants in the study reported in this dissertation represent the phenomenon of sound transmission. I believe that in order for the boys to explore sound transmission, they will also explore the relationship of various aspects of the process. For example, the distance in which

sound travels may be explored with the volume during the process of transmission. In addition, volume may also be explored in relation to how long (duration) the sound lasts. Thus, if the participants incorporate temporal sequencing, it will be interesting to observe its usefulness and if the boys identify the need to represent sound transmission in a way that is not linear.

Manipulation of line segments. Also, within the study of motion, children's abilities to manipulate line segments were identified as constructive resources. Actually, the manipulation of line segments is closely related with the previous resource, temporal sequencing. In reciting their stories within temporal sequencing, children make use of various features of line segments and associate specific meanings to these displayed features. These features may include length, orientation, and/or line thickness (Sherin, 2000). In Figure 8, the students' knowledge of the manipulation of line segments informed the decision to utilize the length of the lines to represent the speed of the vehicle and the size of the circles to represent the varying time in which the vehicle was stationary. In Figure 9, another student uses his knowledge of line orientations in order to represent the changing speeds of a vehicle. The slope of the lines is used to represent the vehicle's varying speeds, with the vertical lines meaning that the vehicle has stopped and the more horizontal lines represent the maximum speed of the car. The increase in the slope of the lines represent a gradual decrease in the vehicle's speed as it approaches a stationary position (i.e., the vertical line in the middle of Figure 9).

Figure 9. Example of temporal sequencing and students' manipulation of line segments (Sherin, 2000, p. 425).

Although students' knowledge of line segments is viewed as a constructive resource in their development of understanding representations, Sherin (2000) also recognized the limitation of this resource. In order for the manipulation of line segments to be successful and develop into conventional use, students must maintain a consistent meaning for their various manipulations, which includes using them at the appropriate times and in the appropriate places. This dissertation's focus on the development of MRC within a group context will specifically highlight the limitation of manipulating line segments. The group's process in attempting to co-construct meaning of the various ways in which line segments are manipulated will allow me the opportunity to examine the beginnings of how notations develop into conventional symbols. Finally, I should also note that while associating slope with speed is very powerful, there remains a gap between the relationship between the line segments in Figure 9 and a conventional representation of speed through slope.

Summary. Through this brief review of literature regarding meta-representational competence, I have been able to identify two types of resources, constructive and critical, within children's representational abilities that I utilize for the research described in this dissertation. My focus on the MRC of a group of African American boys is motivated by a question presented by diSessa and Sherin (2000): "What is the role or possible role of culture in the production of MRC?" (p. 396) Adhering to a dynamic view of culture and the negotiation of children's repertoires of practice (Gutiérrez & Rogoff, 2003), this dissertation specifically connects children's prior knowledge and lived experiences with their production and interpretation of representations of sound transmission. In addition, this dissertation looks to contribute to diSessa's (2004) notion that a MRC focus in science could possibly be an important element in engaging children who have been systematically underrepresented in science careers.

CHAPTER 3:

METHODOLOGY

The qualitative study reported in this dissertation utilized a multi case-study methodology (Yin, 1994) in order to answer the proposed research questions. This methodological approach was appropriate for describing the "complex social phenomena" (Yin, 1994, p. 3) that I attempted to capture within the analysis of this study. Using this methodology afforded me the flexibility of using the analysis to describe the "representational experiences" of a single child, and/or to emphasize specific intellectual and linguistic resources that were identified from various participants within the study. In addition, I had the opportunity to conceptualize specific aspects of sound transmission (i.e., the change in volume of sound as it travels, the omnidirectional aspect of sound transmission) as possible sources for a case study analysis. This methodology was selected to answer the following research questions:

1. What intellectual and linguistic resources do a group of urban, 7th and 8th grade African American boys demonstrate while producing, interpreting, and critiquing invented representations of sound transmission?
2. What ideas, or aspects, of sound transmission do a group of urban, 7th and 8th grade African American boys collectively explore while producing, interpreting, and critiquing invented representations of sound transmission?

3. What is the range of representational features that a group of urban, 7th and 8th African American boys utilize while producing critiquing invented representations of ideas, or aspects, of sound transmission?

My research questions are designed to investigate ways of building upon the intellectual and linguistic resources that a group of African American boys bring to the tasks of producing new representations of sound transmission, as well as modifying previously examined representations. Informed by methods utilized in previous studies that have investigated children's production and interpretation of representations (diSessa et al., 1991; Enyedy, 2005; Lehrer & Pritchard, 2002), I incorporated a combination of semi-structured, clinical interviews (Brizuela, 1997; Duckworth, 1987, 1996; Ginsburg, 1997), videotaped and transcribed exploration sessions, and a total of 79 drawings produced by the boys during the interview and exploration sessions as research tools.

The Sound Transmission Exploration

The primary focus of the four-day exploration was to examine a group of 7th and 8th grade boys' ideas and representations of sound transmission. The exploration sessions happened on consecutive days during a non-scheduled vacation (i.e., the boys were not in school due to a huge snowstorm in the Maryland area). The study was originally an extension of a previous pilot study, in which I explored an elementary school student's ideas of sound transmission and sound absorption through the sense-making practice of embodied imagining

(Keller, 1983; Ogonowski, 2008). The pilot study primarily utilized a discourse analysis methodology (Gee, 2006) that examined the student's talk as the source of data in determining her understanding the scientific phenomena. Building upon the methodology incorporated in the pilot study, the current study provided a group of 7th and 8th grade boys with several shared experiences with sound, as well as examined both their discursive interactions and the drawings produced during these experiences in order to develop an understanding of their thought processes. As opposed to simply focusing on students' talk, as emphasized in the previous pilot study, this study was designed to provide the boys an opportunity to communicate their ideas through an alternate mode of representations, drawing. This exploration was not designed as a formal intervention that intended to "teach" the boys about the science of sound, or to specifically alter or adjust their ideas of sound transmission. On the contrary, the exploration was designed to elicit and document the boys' experiential knowledge and life experiences with sound transmission, and how the boys would collectively construct meanings of sound transmission through representing their experiences (Linder, 1992). A major component in the design and analysis of the activities within the four-day exploration were the critique sessions, where the boys engaged in the practice of analyzing and critiquing the drawings that they created during their exploration.

The Role and Importance of Critique in STEM Disciplines

The activity of critique, or the act of judging the adequacy and quality of a representation and/or idea, is a primary component within the framework of MRC

(diSessa, 2002). How students evaluate the effectiveness of an external representation or an idea is important in identifying students' competencies in understanding and using representations as well as the ideas being represented. The art of critique is a central pedagogical practice within most science, technology, engineering, and mathematics (STEM) programs, where students often develop disciplined habits of mind. In architectural design education, for example, the "architectural critique" is an important pedagogical practice in becoming a competent participant within the discipline. Within the setting of a critique, students are prepared for the daily realities of the role of the architect while presenting, discussing, and defending ideas with clients and other professionals (Melles, 2008). The critique provides the opportunity for students to present their architectural design, typically through detailed drawings and/or models, and to receive feedback from professors and peers (Lymer, 2009). Although the critique is often viewed as a type of assessment, it is also used to teach and familiarize students with the representational competencies and design practices expected within the discipline. For this specific study, I used the architectural critique as a model in developing a space for the boys to present, discuss, and defend their representations and ideas regarding sound and sound transmission. The primary source of data for examining the meanings that the boys constructed regarding sound transmission are extracted from these critique sessions throughout the four-day exploration.

Research Site and Participants

The participants of this study were African American, middle school boys from Baltimore, Maryland. The five boys, Earl, Floyd, Isaac, Kenneth, and Tim[8], reside within the same Baltimore neighborhood and affectionately refer to themselves as the "B-Street Boys," taking pride in their community. Within this neighborhood's sufferance of urban decay, housing abandonment, and crime, I found a wonderful friendship and bond that the boys and their families have developed over a four-year period[9]. When visiting B-Street, one will often find the boys engaged in various athletic activities (i.e., American touch football or basketball), skateboarding, playing games such as hide-and-go-seek, or simply "hanging on the block."

The B-Street Boys were specifically chosen as the participants of this study because of its focus on recognizing and identifying the intellectual and linguistic resources utilized by African American boys. The boys all attend different schools within Baltimore City, where academic achievement for African American boys has been challenging. The estimated high school graduation rate for African American males in Baltimore City during the 2007-2008 academic year was 35% (Schott Foundation, 2010). Specifically focusing on the area of science education, 68% of Baltimore's 2009-2010 African American males in middle school scored within the "basic" range on Maryland's statewide

[8] Pseudonyms are used to protect the privacy of the children and their specific neighborhood.
[9] Four years ago, Floyd, Tim, and Isaac's families moved to the neighborhood (at different moments), while Earl and Kenneth's families were already residents of B-Street. Earl and Kenneth knew each other prior to the four-year window, but became good friends as the five boys developed a group friendship.

assessment[10] (Maryland Report Card, 2010). Due to these circumstances, the B-Street Boys would typically be categorized as "at-risk" within their schools.

At the time of the study, Floyd and Isaac were 13-year old eighth grade students, at different schools, who had both previously expressed an excitement for science learning. Floyd is a very outgoing child who had been voted the class President for his middle school and will be matriculating to a Baltimore area parochial high school. In addition, he had expressed a desire to pursue a future career in engineering, in order to design assistive devices that would support individuals like his sister who has cerebral palsy. Isaac is also a very outgoing, and outspoken child who will be matriculating in the STEM focused high school within the Baltimore area. Earl and Kenneth were 13-year old seventh grade students, who had been previously held back for one year in school and would have belonged in the eighth grade. Both of these boys expressed some liking of the study of science, in general. Finally, Tim was a 12-year old seventh grade student that did not have much affection for science, but participated in this particular study because of his close relationship with the other boys. I specifically describe the boys' previous academic experiences and the "at-risk" label that would typically be applied to them within an academic institution to highlight the deficit-oriented methodological approaches and views that most studies would use to situate the experiential knowledge and life experiences of these boys. In contrast, this study looked to serve as a counter-narrative to

[10] As noted by the 2010 Maryland Report Card, the "basic" standard is a level of achievement indicating more is needed to attain proficiency in meeting the needs of the students.

previously described research and instructional goals that often serve to stigmatize and undermine the intellectual capacity of African American boys.

The Role of the Researcher

As the principal investigator conducting this study, I served as the designer and facilitator of the four-day sound exploration. Using experiences from previous work with children and their ideas regarding sound transmission, I designed shared experiences with sound and explanatory questions that guided the boys' experiences within the four sessions. In addition, I served as the facilitator that implemented the exploration. Prior to the facilitation of this exploration, I had an established relationship with the boys and their families, thus allowing for group discussion that was more conversational in nature, and less like discussions often experienced within academic institutions. Although I was viewed as a "science expert" within the group, I believe that the boys were comfortable with expressing and debating their ideas regarding sound transmission, without the pressure of believing that I would explicitly address any presented incorrect ideas or conceptualizations. To ensure that this belief was evident throughout the group, during the initial session, I explicitly informed the group that my questions for them were for clarification only and not intended for assessment. I was present for each of the four explorations.

Individual Interviews

Each boy participated in a pre-exploration and post-exploration interview during this study. Each interview was designed as a semi-structured, clinical interview (Brizuela, 1997; Duckworth, 1987, 1997; Ginsburg, 1997) that used the boys' responses and explanations for the generation of clarifying questions regarding the boys' understanding of sound transmission and the ways to represent this process. Within each interview, the boys were presented with three different drawing tasks designed around representing sound and sound transmission.

In the pre-exploration interview, the first drawing task asked the boys to draw how the sound from a musician's guitar would reach the audience (see Figure 10). Following the drawing task, boys were asked to explain their drawing and clarifying questions were generated from their responses.

Figure 10. Illustration used in interview drawing task #1.

The second drawing task, again asked the boys to draw how sound from a musician's guitar would reach an audience, except the second illustration was from a bird's eye perspective (see Figure 11). Following the drawing task, the boys were asked to explain their drawings and clarifying questions were generated from their responses.

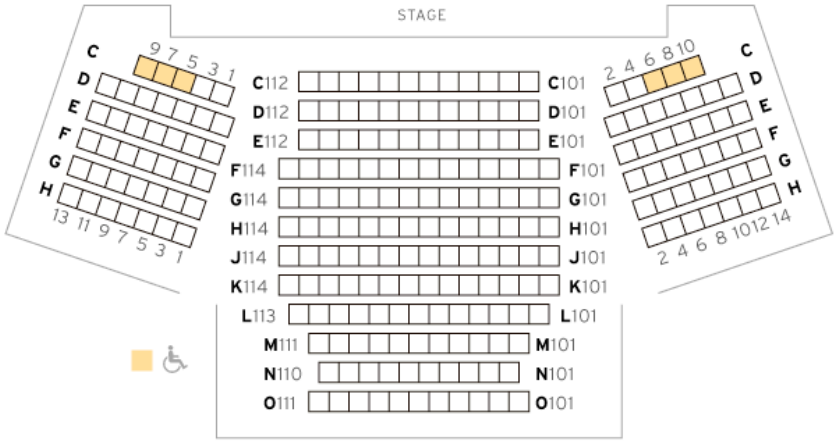

Figure 11. Illustration used in interview drawing task #2.

The third drawing task asked the boys to complete an architectural site analysis for sound on a provided architectural site map (see Figure 12). The site map presented the boys with five different sources of sound, a busy street or highway (see "A" in Figure 12), an airport (see "B" in Figure 12), a construction site (see "C" in Figure 12), a children's playground (see "D" in Figure 12), and a less-traveled street (see "E" in Figure 12). The boys were asked to imagine each of the sounds and to draw how the sound from each source could reach the proposed building site (see closed shape, outlined using dashed lines in Figure 12). After the boys completed the site map, they were asked to explain their

representations. Follow-up questions typically included how they represented variation in volume between the sound sources and the boys' intentions for selecting notations for sound and sound transmission.

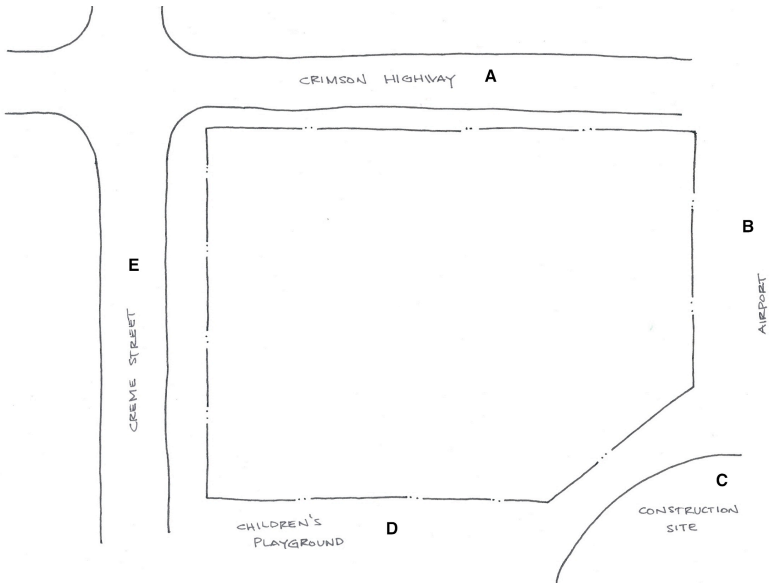

Figure 12. Illustration used in interview drawing task #3.

The post-exploration interview followed the same format as the pre-exploration interview, except that the boys had the opportunity to reflect and comment on their initial representations (produced during the pre-exploration interview) of sound transmission. The boys were presented with the same drawing tasks and images as in the pre-exploration interview, so that they could compare and contrast their understanding of sound transmission and how it could be represented. In addition, the boys were presented with two different and completed architectural site maps (see Figure 13 and Figure 14). The boys were asked to describe what they thought each figure was attempting to communicate, such as which notation utilized in the site map communicated the loudest volume

or the sound that lasted the longest time (duration). After the boys analyzed each site map separately, the site maps were compared and contrasted with regard to the drawing's choice of notations and the information that was being represented.

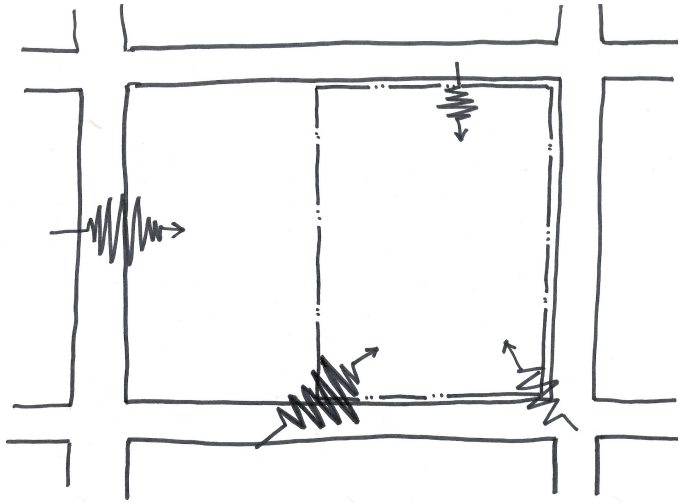

Figure 13. Sample architectural site map #1 for the post-exploration interview.

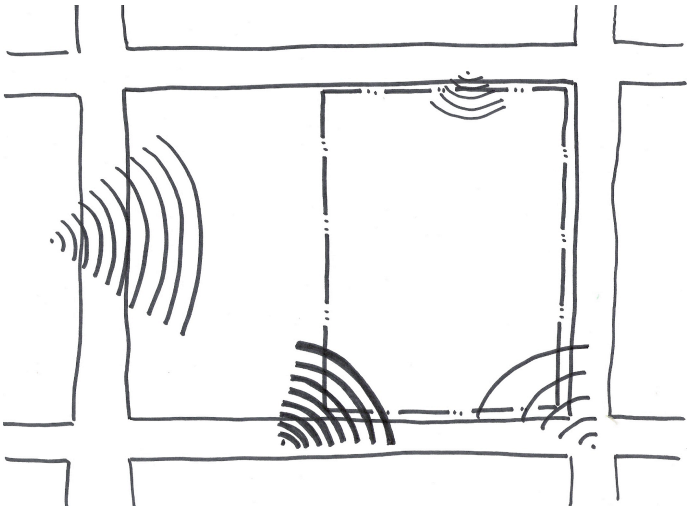

Figure 14. Sample architectural site map #2 for the post-exploration interview.

The Sound Exploration

Sound exploration Session One: "Where does the sound go?" Within Session One, the boys participated in shared experiences of listening to sound generated from a tambourine. Earl, Floyd, Kenneth, and Tim were present during Session One (Isaac was absent). These shared experiences were used to facilitate group discussions and individual representational practices. The boys engaged in discussion and drawing of the tambourine's sound transmission within three different contexts, including: 1) experiencing the sound from within the same room, 2) experiencing the sound from an adjacent room with an open doorway, and 3) experiencing sound from an adjacent room and through a solid barrier, such as a solid wall and a closed door. These shared experiences were important in grounding group discussions and the ideas that the boys represented through their drawings.

Following each of the described experiences with the tambourine's sound, each boy created a drawing that illustrated his ideas on how the sound would reach their ears (Barman, Barman, & Miller, 1996). Following the boys' creation of these drawings, they engaged in a group and self-critique period focused on their individual drawings. For example, after experiencing the tambourine's sound from within the same room, each boy, individually, created a drawing depicting how sound would reach their ears. After completing the drawings, each drawing was displayed for the group for individual analysis. The first boy placed his drawing at the center of the table and the group discussed and negotiated their ideas of what made this particular drawing an accurate or inaccurate

representation of sound transmission. This process was followed for each child, and after each group experience of the tambourine's sound.

Session One concluded with the group providing their critique of a sample architectural site analysis (see Figure 15). When the site map was presented to the group, they were asked: 1) "what kind of things do you notice on the site map?", 2) "what is being communicated through the drawing?", and 3) "is this a good way to represent sound?"

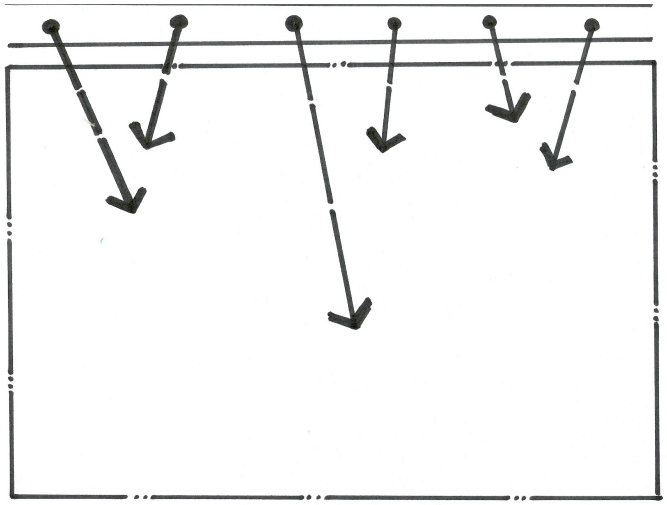

Figure 15. Sample architectural site map used in Session One (White, 2005, p. 109).

Sound exploration Session Two: "What is a sound wave?" Session Two served as an extension of Session One. During Session One, the idea of sound waves was introduced by the boys, and became a major topic of discussion and explanations used for describing sound transmission. Earl, Floyd, Isaac, and Kenneth were the boys present for Session Two (Tim was absent). To build upon the boys' interests and the idea that they wanted to explore further, Session Two

was designed to continue the exploration around the idea of sound waves.

Initially, the boys were asked to draw their representation of sound wave(s). Upon completion of these drawings, the boys engaged in a critique session, similar to their experiences from Session One, where they analyzed each boy's drawing for accuracies or inaccuracies. Again, the boys' talk and drawings were the primary focus of the beginning of Session Two.

Following this initial talk and period of drawing, the majority of Session Two was designed to analyze, discuss, and critique other representations of sound waves (i.e., images, photographs, and animations). During this period of Session Two, the boys were provided the opportunity to examine three images of sound waves, and an animation of the process of sound transmission. The sound wave images that the boys examined and discussed are provided in Figure 16, 17, and 18. Following the discussions around the three images that I provided, the boys also participated in a discussion regarding sound transmission, using an animation as a foundation for the discussion (see Figure 19). Session Two concluded with the boys creating another drawing of their ideas of sound waves, following the discussion and analysis of the images and the animation.

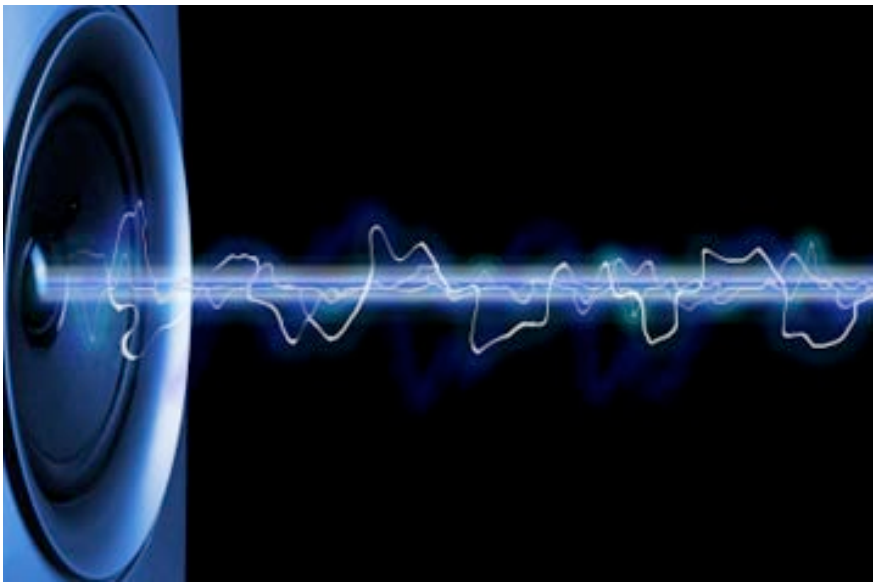

Figure 16. First example of sound wave image (Image retreived from http://allgraphicsonline.com/q/soundwaves+mathematics+graphics/).

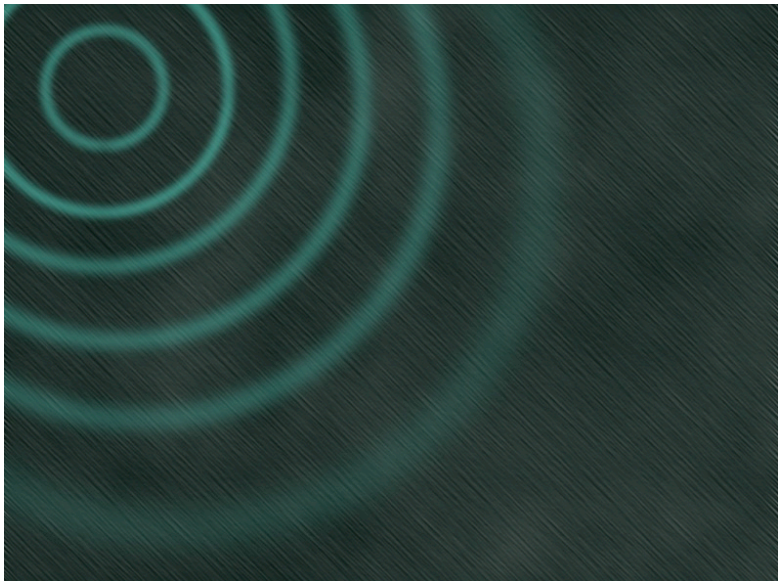

Figure 17. Second example of sound wave image (Image retrieved from http://www.ekojanchi.com/Old_site/design.htm).

http://www.ekojanchi.com/Old_site/design.htm

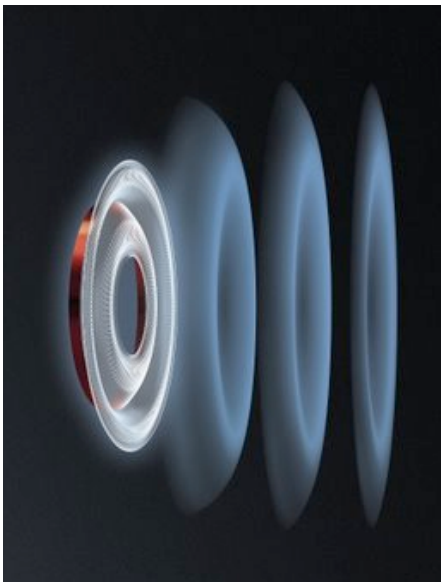

Figure 18. Third example of sound wave image (Image retrieved from http://techgeek.com.au/2009/01/11/sennheiser-brings-out-new-high-end-headphones-for-the-audiophile-in-you/).

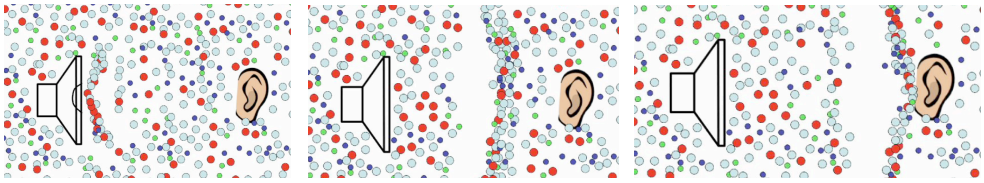

Figure 19. Images from the animation that the boys analyzed.

Sound exploration Session Three: "Drawing sound transmission." Session Three was designed to provide the boys with another shared experience of sound transmission, with further opportunities to discuss the experience through debate and drawings. All five of the boys, Earl, Floyd, Isaac, Kenneth, and Tim, were present for Session Three, as well as for Session Four. Initially, the boys closed their eyes and silently listened to the surrounding sounds for approximately 3-4

minutes. Following this experience, they engaged in a discussion of describing the sounds that each experienced. Example descriptions included talk about the source of the various sounds, the intensity of various sounds, the duration of sounds, and the various pitches heard by the group. Following this disucssion period, each boy created a drawing that represented how 2-3 sounds reached them within the house. The opportunity to create this particular drawing required the boys to distinguish between sounds within the house and sounds from outside the house, and how both reached them within the house. Following the design of these drawings, the group engaged in a critique session, much like the previous critique sessions utilized during Sessions One and Two. Each boy individually presented their drawing to the group and the drawing was analyzed, discussed, and debated.

Following the boys' production of drawings, the group engaged in the interpretation and critique of architectural site maps that were previously created by professional architects (see Figure 20 and Figure 21). Each site map was originally analyzed and discussed separately, and then compared and contrasted with each other. The comparing and contrasting provided the boys an opportunity to highlight how specific notations functioned to accurately or inaccurately reprsent specific aspects of sound transmission (i.e., duration of the sound, the intensity of the sound, or how the sound would travel).

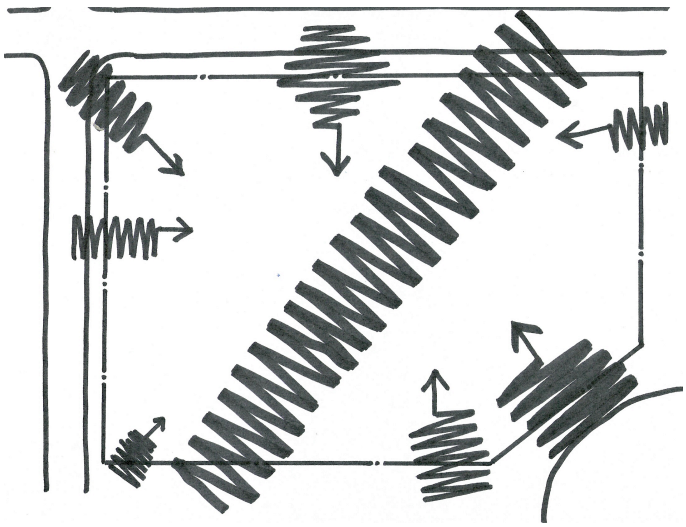

Figure 20. First architectural site map for analysis

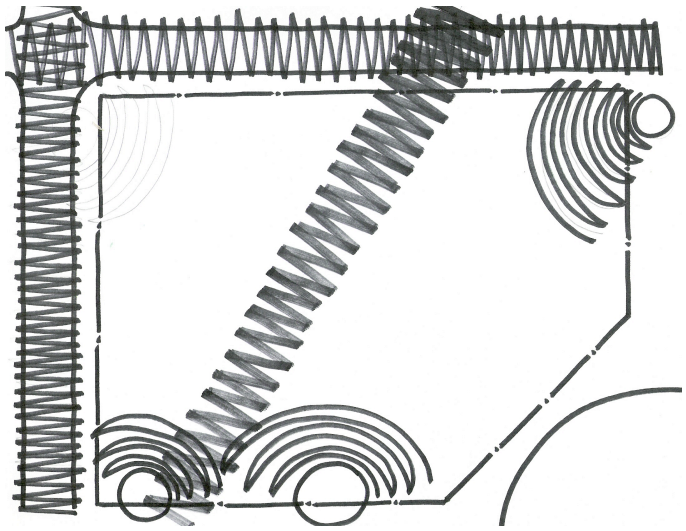

Figure 21. Second architectural site map for analysis

Sound exploration Session Four: "Sound waves revisited." Session Four was designed to provide the boys with their final opportunity to discuss and represent their ideas on what constituted sound waves and how sound travels. The session began with another discussion on defining sound waves. Following this

discussion, the boys were provided with several scenarios that they represented through a drawing. First, they were asked to draw a loud volume and a quiet volume. Following this representation, each individual drawing was analyzed in order to highlight and discuss the various notations utilized to focus on volume. Next, the boys were asked to draw a sound that lasted 1 minute, a sound that lasted 5 minutes, and a sound that lasted for 30 minutes. Again, the group analyzed individual drawings for the various notations utilized to highlight the duration of the sound. Lastly, the boys were asked to draw sound traveling through a "theatre" curtain and the group engaged in a similar analysis and critique.

Group Design and Discussion Sessions

Each of the student's interviews and each of the previously described group design and critique sessions were videotaped and later transcribed. This data source was designed to provide me the opportunity to identify, explore, and analyze the varieties of sense-making practices utilized by the boys within individual interviews, as well as throughout the four-day exploration of sound transmission. Specifically, the boys' communicative practices were examined through their verbalizations and gestures utilized during the design and critique of their invented representations.

Videotapes from the four-day exploration were examined, and later transcribed, after each exploration session (Roth, 1996) in order to preliminarily identify possible sense-making resources to build upon in later sessions. The goal

of this data source was to longitudinally capture and document the group's discussions and practices while exploring sound and sound transmission. Transcripts have been an integral data source for previous studies also investigating student sense-making (Michaels & Sohmer, 2000; Warren et al., 2005), as well as my pilot study on children's ideas of sound transmission and sound absorption (Wright, 2009). Utilized together, videotapes and transcripts served as valuable data sources in exploring each of the three stated research questions.

Student Drawings of Sound and Sound Transmission

Student invented representations, or drawings, of sound and sound transmission constituted another source of data for this study. Drawings were collected from the boys' pre and post-exploration interviews and from the four sound exploration sessions. During the pre and post-exploration interviews, the boys produced three different representations of sound transmission (see the Individual Interviews description earlier in this chapter for details). Task #3 in the interview was designed using a similar architectural map that was previously presented and completed by professional architects (White, 2004).

In addition to the drawings collected from the individual interviews, I also collected the boys' drawings from each of the individual group sessions. The boys created 4 drawings each during Session One, 2 drawings each during Session Two, 2 drawings each during Session Three, and 3 drawings each from Session

Four. Drawings were completed by individual boys and later examined and critiqued by the entire group.

Data Analysis

The analyses of the collected data focused on answering the primary research questions by examining the group design and critique sessions, and the drawings that were generated during these sessions. The analyses focused on the following:

1. The boys' intellectual and linguistic resources during the construction of scientific understanding and critique of invented representations.
2. The ideas, or aspects, of sound transmission that the boys deemed important to highlight within their drawings.
3. The range of representational features that the boys utilized to highlight the important ideas, or aspects, of sound transmission.

Research question #1: Recognizing the boys' intellectual and linguistic resources. In order to answer the first research question, "what intellectual and linguistic resources do a group of urban, 7th and 8th grade African American boys demonstrate while producing, interpreting, and critiquing invented representations of sound transmission" (research question #1), I examined transcripts from the boys' group exploration and critique sessions. Previous literature, focusing on identifying the intellectual and linguistic resources that some children from communities of color have demonstrated during science learning, was identified

as an initial list of resources to look for. The initial list included resources, such as: embodied imagining (Ogonowski, 2008), varied forms of argumentation (Ballenger, 1997; Hudicourt-Barnes, 2003), narratives and/or storytelling (Warren at al., 2005), and metaphors and/or analogies (Ballenger, 1997).

After examining the transcripts from each of the four sound exploration session, I was able to identify and focus on the boys' intellectual and linguistic resource of *Signifying* (Gates, 1989; Lee, 2000; Mitchell-Kernan, 1977; Smitherman, 1977) to collectively construct meaning regarding sound transmission and the representations utilized to represent this phenomenon. Specifically, the analysis focused on the boys' use indirection/innuendo, braggadocio, and sarcasm/irony during this exploration. Although this was not the only resource identified, my goal was to provide a detailed description of how a resource could be utilized to enhance the boys' experiences within a science learning environment.

Research question #2: Identifying the sound transmission ideas that the boys highlight. In order to answer the question, what ideas of sound transmission do the boys collectively explore, I examined transcripts from group exploration and critique sessions. In addition, I analyzed the drawings that were generated during these sessions. I specifically highlighted and focused on how the boys talked about and represented three ideas of sound transmission: 1) the reflectivity of sound waves, 2) the change in volume over distance, and 3) the omnidirectional aspect of sound transmission.

Research question #3: Identifying the variation in using representational features. In order to answer the question, what is the range of representational features that the boys utilize regarding the idea of the change in volume over distance, I again examined the transcripts from group exploration and critique sessions and the drawings produced during these sessions. Using Sherin's (2000) model of focusing on the representational features that children utilized in representing motion, I focused on the elements of drawing, temporal sequencing, and the manipulation of line segments within the boys' drawings and the explanations that accompanied these drawings. As the boys progressed through the four-day exploration, I also tracked how these elements remained the same, were modified, or were changed completely in order to address the aspects of the change in volume over distance that the boys were highlighting. This analysis provided me with the opportunity to construct a description of the boys' competencies in modifying and creating representations.

CHAPTER 4:

CO-CONSTRUCTING IDEAS OF SOUND TRANSMISSION

This chapter is concerned with examining the research question, *What ideas regarding the science of sound transmission do the B-Street boys highlight as they interpret and critique drawings representing sound transmission and how are the understandings of these ideas co-constructed through the boys' talk?* Using a discourse analysis approach (Gee, 1999) to prioritize the boys' linguistic practices while discussing various ideas of sound transmission, I trace the boys' conversations during their critique of drawings representing sound transmission. Specifically, the analysis in this section examines the boys' conversations regarding five drawings created by individual group members, the first drawing created by each of the five boys. Four of the five boys' conversations and drawings will be from Session One, while one boy's (Isaac) conversation and drawing will be from Session Two because he was absent for Session One. So, Session Two was his "first" session. During the boys' interpretation and critique of these drawings, the group highlighted and focused their discussions around a range of scientific ideas regarding sound transmission, including: 1) *directionality* (sound transmission as omnidirectional), 2) *distance* (the distance in which sound waves travel), 3) *reflectivity* (the reflection of sound waves), 4) *pitch* (the frequency of sound), and 5) *volume* (how volume changes during the process of sound transmission).

The analysis reveals that the boys constructed a shared language in describing the ideas of sound transmission that they deemed important to

highlight. In addition, the drawings played a prominent role in contributing to the sound transmission ideas that the boys recognized and further reflected upon through their talk.

Along with identifying the ideas of sound transmission that the boys highlight, this chapter is also concerned with the research question, *what intellectual and/or linguistic resources do the B-Street boys demonstrate while critiquing invented representations of sound transmission?* Specifically, this chapter highlights the African American linguistic practice of *Signifying* (Gates, 1984; Lee, 2000; Mitchell-Kernan, 1977; Smitherman, 1977; Spears, 2007) as a primary resource that this group of boys used as they collectively engaged in discussions about the science of sound and how to represent their experiences with sound transmission. This part of the analysis reveals that the boys incorporated well-known elements of *Signifying,* including: indirection / innuendo, braggadocio, and sarcasm / irony, not only as social functions, but also as a method for problematizing[11] (Barton, 2000) ideas, assertions, and representations of sound transmission. By doing this, the boys' community-based linguistic practices facilitated a deeper reflection on the scientific ideas generated through analyzing their drawings representing sound transmission.

"Where does the sound go?" – A Description of Session One

[11] Problematize is used to denote the boys' process of making a problem out of or questioning each other's ideas, assertions, or individual drawings. The questions utilized within this process are intended to extend the conversation regarding an idea, assertion, or drawing in order to address unsettled elements or uncertainty (Barton, 2000).

Session One of the four-day exploration of sound was designed to explore the B-Street boys' initial ideas regarding sound transmission. Specifically, the shared experience of listening to sound generated by a tambourine was used to facilitate group discussions, which then informed the boys' production of representations. For this chapter, I will utilize the group conversations about the transmission of the tambourine's sound from within the same room (the first experience). This shared experience was important in grounding group discussions and the ideas that they elected to highlight in their subsequent conversations and within their drawings. The initial analysis will focus on the conversations by the four group members present for Session One, Earl, Kenneth, Floyd, and Tim. The conversations will be presented in chronological order, as drawings were introduced to the group for analysis, and will begin with the critique of Earl's drawing.

Student 1: Earl

"It's a lot of waves going everywhere:" Developing Language for Directionality and Distance

After experiencing the tambourine's sound within the same room, the boys were asked to think about and briefly discuss how the sound got from the tambourine to their ears, and to represent their ideas through drawing. Then the boys' drawings were taken one by one, and each was examined and critiqued individually. Earl's drawing (see Figure 22) was first to be critiqued; as such, in

Excerpt 4.1, the boys are discussing for the first time the sound transmission ideas that they interpreted from reading a drawing created by one of the boys.

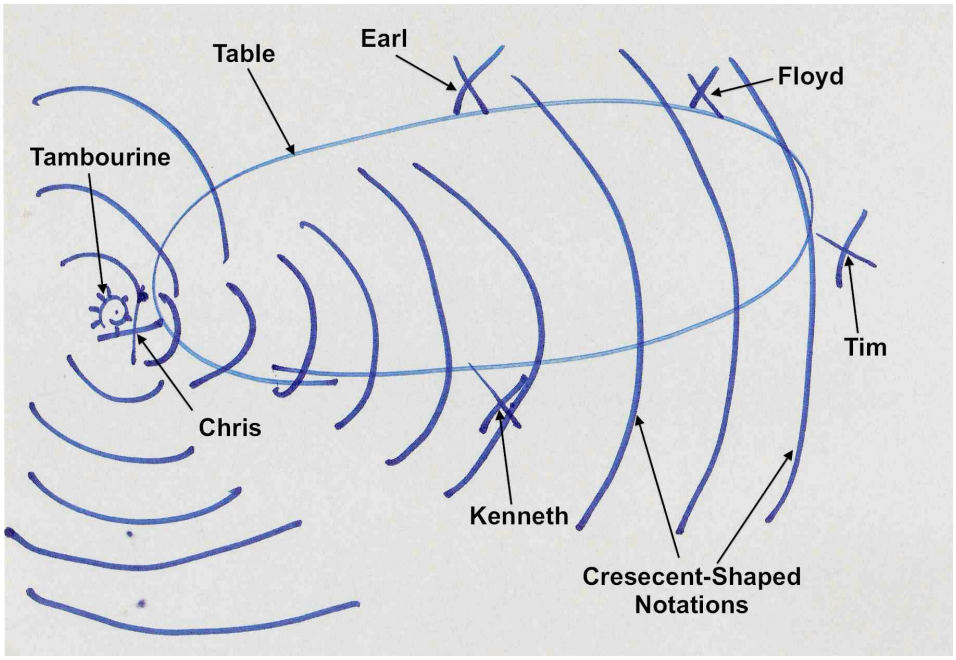

Figure 22. Earl's 1st drawing representing sound transmission[12].

To begin the interpretation of Earl's drawing, I asked, "What do you notice about Earl's drawing?" The boys' initial exchange is documented in Excerpt 4.1:

Excerpt 4.1. What do you notice about Earl's drawing[13]?

1. Floyd: It's a lot of <u>waves</u> (.) going everywhere.

2. Tim: A lot of waves.

[12] Although the figures include pictures of the actual drawing produced by the boys, I added the clarifications (e.g., tambourine, table, crescent-shaped notations) to each of the drawings.

[13] I use the following transcription conventions: timed paused (1.8), measured in seconds, indicates an interval of silence; (.) indicates a brief pause; ? indicates rising pitch or intonation that may or may not have the grammatical structure of a question; ! indicates the conclusion of an utterance delivered with emphatic and animated tone; -- indicates self-interruption; >< indicates a portion of an utterance delivered at a noticeably quicker pace than surrounding talk; <u>underscore</u> indicates stress on a word or syllable; (word) indicates uncertainty on the transcriber's part but represents a likely possibility; ( ) indicates that something was said but it could not be heard; (…) indicates talk; // indicates over-lapping speech; (()) indicates researcher annotation (Rosebery, Ogonowski, DiSchino, & Warren, 2010).

3. Earl: I'm an artist (artiste).

4. Kenneth: They're [sound waves] going everywhere.

5. Chris: They're going everywhere, okay. You said a lot of waves, they're going everywhere. What else?

6. Floyd: It's a bad drawing. Sike[14].

7. Kenneth: They [sound waves] go pretty far.

8. Chris: They go pretty far?

9. Floyd: Yeah.

10. Chris: How do you know that they go pretty far?

11. Kenneth: Because, the sound waves come past the table.

12. Chris: Okay.

13. Floyd: They go to the furthest point of the room, which is Tim. [Tim looks behind himself, as if to indicate that there is more space behind him.]

14. Chris: Anything else you noticed?

15. Floyd: They go in all directions.

16. Chris: Okay, so what do you think the drawing is telling you?

17. Floyd: That sound travels in all directions //

18. Tim: Yeah, that sound travels.

19. Kenneth: It goes everywhere.

20. Chris: Do you all agree with the drawing? Or, is it a good job at showing the sound traveling that way?

[14] "Sike" is a slang term that is meant to be either sarcastic, a joke, or both. The term basically means, "just kidding," and is typically used to negate whatever statement that came before it's use.

21. Floyd: I guess so, yeah.

22. Chris: So, you guess so means that it could be yes or no, right?

23. Floyd: Yeah.

24. Chris: So, why would you say no then?

25. Floyd: Well, now that I talk and think about it, I don't think mine was [correct] either. Seeing that sound travels everywhere, there should be a wave everywhere.

26. Chris: There should be a wave everywhere?

27. Floyd: Yeah.

28. Chris: What do you mean? Like this [referring to Earl's drawing] or like something else?

29. Floyd: Like it; there should be a wave everywhere around the room.

30. Kenneth: I agree with Floyd. I think sound waves should be everywhere. Because it's going left, right, and up, then at some point, they will eventually meet or sound waves will be going everywhere all over.

31. Chris: Okay.

32. Kenneth: Even behind you.

The boys' exchange documented in Excerpt 4.1 is important because it marks the genesis of the group's grappling with a range of scientific ideas regarding sound transmission and how to represent these ideas as they focus on interpreting Earl's drawing. One idea highlighted by the boys was the *directionality* of sound transmission. Typically, sound waves generated from a point source move out

spherically from the source (see Figure 23; Serway & Jewett, 2003). A point source is a source of sound occupying a very small area and having a concentrated output, like the use of the tambourine in the current study. In addition, as the waves move out from the source, they become less intense. Within the following subsection, I provide an analysis of the boys' conversations regarding two sound transmission ideas: the *directionality* of sound transmission and the *distance* in which sound waves travel.

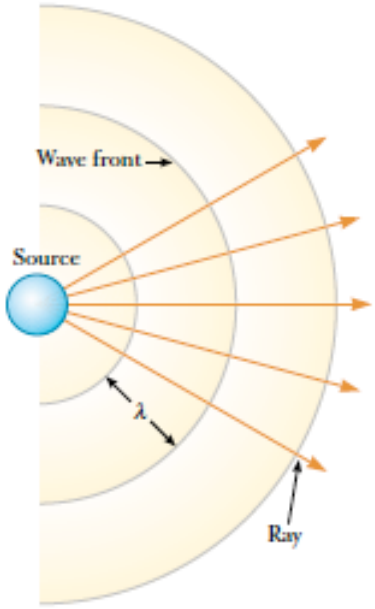

Figure 23. Representation of the spherical travel of sound waves (Serway & Jewett, 2003, p. 528).

Directionality. Directionality was one of the first sound transmission ideas the boys identified and highlighted during their interpretation of Earl's drawing (see Figure 22). The boys' linguistic use of *"going everywhere"* and *"going in all directions"* emerged as the primary descriptors for the directionality of sound

transmission. Initially, Floyd (line 2) sees the sound waves in Earl's drawing as *"going everywhere,"* which I interpreted as Floyd focusing on the directionality of sound. Kenneth (line 4) later takes up the idea of directionality, as he utilized Floyd's earlier language and also described the sound as *"going everywhere."* Kenneth (line 19) and Floyd (line 25 and line 29) continued their use of *"going everywhere"* throughout their examination of Earl's drawing, thus "going everywhere" emerged as a primary way to talk about their understanding of directionality of sound transmission. However, Floyd (lines15 and 17) also introduced a different descriptor, as he explicitly described the sound as *"going in all directions."* Despite this introduction of new language for directionality, Floyd and Kenneth maintained their use of *"going everywhere"* during the analysis of Earl's drawing, thus implicitly assuming that these terms are synonymous.

In addition to exploring their language when describing directionality, the boys were simultaneously exploring their understanding of directionality itself. I specifically unpack Floyd's utterance (line 25) as evidence of the boys' exploration and continued evaluation of their understanding of directionality. Here, Floyd explicitly stated that at some point during the critique of Earl's drawing he recognized a discrepancy in Earl's drawing and it made him evaluate his own drawing, as he stated, *"Now that I talk and think about it, I don't think mine was [correct] either."* In this utterance, Floyd has re-evaluated his prior understanding of Earl's drawing as representing the directionality of sound transmission as "going everywhere" or "going in all directions." He even extended this evaluation process as he envisioned his own first drawing in relation

to this developing understanding of directionality and how to represent it, and concluded that his drawing is probably also inaccurate. Through a process of analyzing Earl's drawing, Floyd has problematized (Barton, 2000) the group's understanding of directionality and the methods for accurately representing the idea. Later, Kenneth (line 30 and line 32) built upon Floyd's recognition of possible discrepancies in Earl's drawing and explicitly identified that the sound waves should be represented as also traveling *behind* the source of the sound. Analyzing Floyd and Kenneth's arguments, I see that they do not believe that Earl has accurately represented the sound waves as traveling behind the source of sound (see Figure 22). Although I cannot definitively suggest that Floyd and Kenneth did not previously believe that sound waves should travel in all directions, including behind the source, I do argue that the boys' reading and analysis of Earl's drawing impacted their talk regarding directionality and how the idea should be represented in drawings.

Distance. The second sound transmission idea highlighted during the analysis of Earl's drawing was the distance in which sound waves travel. The boys' consensus for this idea was that the sound waves *"go pretty far."* The talk of the sound waves going pretty far was initially introduced by Kenneth (lines 7 and 11) and later taken up by Floyd (line 13). The boys' understanding of this idea directly coincided with what they were reading in Earl's drawing. Since the sound waves were drawn to reach Tim (see Figure 22) who was seated at the

greatest distance from the sound source, Kenneth and Floyd interpreted the sound as simply traveling far.

Summary. In summary, I believe that Floyd and Kenneth's initial observations of Earl's drawing promoted group talk and analysis of two sound transmission ideas: 1) *directionality* of sound transmission and 2) the *distance* that sound waves travel (see Table 3 below). The boys' ways of talking about these ideas while analyzing Earl's drawing will serve as an anchor as I trace how their talk and understandings developed while examining the remaining drawings. In addition, although I recognize that the boys talked about other ideas represented in the drawing (e.g., the quantity of sound waves and "a lot of waves"), I focus on directionality and distance as primary ideas because of the ways the boys' understanding of these ideas developed during the subsequent conversations. Next, Kenneth's drawing is analyzed for the group's continued development about the ideas of directionality and new idea, reflectivity.

Table 3

Sound transmission ideas discussed during the critique of Earl's drawing

Analyzed Drawing	Directionality	Distance Traveled
Earl	•	•

Student 2: Kenneth

"And they're just going, expanding:" Continuing to Discuss Directionality and Introducing Reflectivity

After analyzing Earl's drawing, the boys took up Kenneth's drawing (see Figure 24). As before, I initiated the discussion by asking them what they noticed about Kenneth's drawing (see Excerpt 4.2).

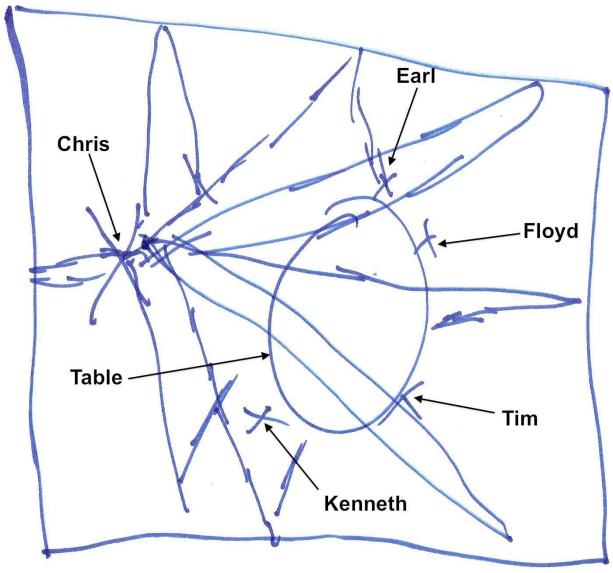

Figure 24. Kenneth's 1st drawing representing sound transmission.

Excerpt 4.2. What do you notice about Kenneth's drawing?

1. Chris: So, what did you all notice on that one? [The boys burst into group laughter.] So, what's happening here, anybody know?

2. Floyd: I don't know. There's some lines going around bouncing off walls.

3. Kenneth: Yeah.

4. Chris: It's some lines bouncing off walls?

5. Floyd: Yeah.

6. Chris: So, you just said bouncing off walls, so what do you think's going on then?

7. Earl: It sounds terrible.

8. Floyd: ()

9. Chris: That what?

10. I don't know what that [referring to Kenneth's drawing, in general] say.

11. Chris: So, what do you think Tim?

12. Tim: The same thing, that sound travels.

13. Chris: That sound travels? All right, how about you, Earl?

14. Earl: I think he could have made his waves a little bit different. [The group continues to laugh.]

15. Chris: How so?

16. Earl: Because it's just a bunch of lines starting off from you [the sound source] at. And they're just going, expanding throughout the room.

17. Chris: Okay. Kenneth, why did you make - I see that it's not like a straight line, per se, but it's like a little scratch in it almost?

18. Earl: I just noticed that.

19. Kenneth: Yeah, because those are lower pitches.

20. Chris: Oh, okay. Those are pitches. So, what does each little scratch mean then?

21. Kenneth: When it gets lower and lower.

22. Tim: Higher and higher.

The boys' analysis of Kenneth's drawing primarily focused on two sound transmission ideas: the *directionality* of sound transmission and the *reflectivity* of sound waves. Typically, when sound waves from a point source hit a flat surface (i.e., the walls of the room that the boys are within for the study), the waves will bounce off in the direction that is opposite of where the original sound waves came from (see Figure 25; Hewitt, 2002). Sometimes, as sound reflects from the walls, ceiling, and floor of a room, these surfaces are too reflective and could cause the reflected sound to become distorted. Within the following subsection, I provide an analysis of the boys' continued talk regarding *directionality,* while also examining their introductory talk regarding *reflectivity.* In addition to these two ideas, Table 4 (see page 92) also indicates the group's identification of a third idea: the pitch of the tambourine. This idea was highlighted by Kenneth (line 19 and line 21), but was not expanded upon during this or future conversations. For this purpose, I did not dedicate a separate analysis to this idea, but provided a brief acknowledgment of its introduction by including it in Table 4.

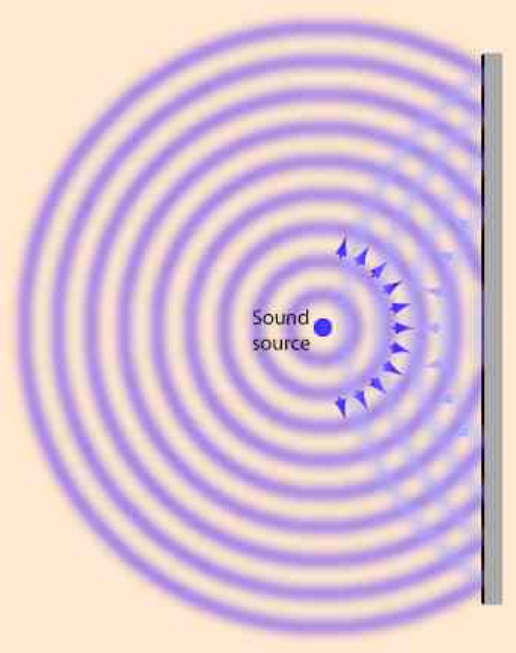

Figure 25. Representation of sound transmission generated from a point source and reflecting off a flat surface (Image retrieved from http://hyperphysics.phy-astr.gsu.edu/hbase/sound/reflec2.html).

In addition, in regards to Kenneth's drawing, I want to briefly consider the group's initial reaction to Kenneth's drawing (line 1). Upon first viewing Kenneth's drawing, the boys burst into group laughter and they did so again later during the critique (line 14). In line with my description of sarcasm / irony in Chapter Two, the boys' laughter may appear as a mocking and cruel reaction to Kenneth's drawing to those unfamiliar with *Signifying*. However, the boys' laughter was meant to convey -- and was taken up as -- a humorous, "insider" act in order to problematize the drawing that was put before them. As in most acts of

Signifying, especially the Dozens[15], the boys' laughter is an approved method of talking about someone or something in the group and participants are not expected to take the humor to heart. In this instance, Kenneth understood the role that the laughter was meant to play and engaged in similar acts of *Signifying* at other times during our sessions together.

Directionality. The boys, again, recognized and talked about the idea of directionality as they interpreted and critiqued Kenneth's drawing (see Figure 24). The boys' talk regarding directionality in relationship with Kenneth's drawing was constructed from their disagreement with how Kenneth represented the idea. Specifically, I highlight Floyd (line 2) and Earl's (line 16) utterances and linguistic practices as they focus on directionality. First, in his utterance (line 2) that Kenneth's lines are *"going around bouncing off walls,"* Floyd focused on the idea of directionality by focusing on where the waves were traveling, as he did earlier when analyzing Earl's drawing (see Excerpt 4.1, lines 17 and 25). However, his talk regarding directionality in Kenneth's drawing contrasted with his previous language use in which he described Earl's waves as "going everywhere." In responding to Kenneth's drawing, Floyd's talk included elements of *indirection* (Mitchell-Kernan, 1999; Smitherman, 1977) in order to underscore his view that Kenneth's representation of directionality appeared haphazard or random. Floyd's use of indirection during his critique of Kenneth's drawing is

[15] As noted earlier, "The Dozens" is an element of African American oral traditions where, typically, two competitors engage in a competition of good-natured insults or trash talking (Lee, 2000). The Dozens is a culturally approved method of talking about somebody, while at the same time, participants are expected not to take any of the humor to heart (Smitherman, 1977).

denoted by his choice of language, as he chose to use *"going around"* as opposed to the more explicit use of *"going everywhere"* or *"going in all directions."* By juxtaposing the language of "going around" with his consistent use of "going everywhere" or "going in all directions" during the critique of Earl's drawing, Floyd highlighted his belief that Kenneth's drawing was inaccurate.

Next, while describing how Kenneth could have drawn the waves differently, Earl (Excerpt 4.2, line 16) stated, *"It's just a bunch of lines starting off where you at. And they're just going, expanding throughout the room."* Initially, I focus the analysis on Earl's use of *"just going,"* as I argue that he is also highlighting his interpretation that Kenneth's approach to representing directionality is haphazard. Although Floyd and Kenneth's language originally utilized the descriptions of "going everywhere" and "going in all directions," when Earl's use of "just going" is contrasted with the boys' earlier talk it denotes his focus on directionality in Kenneth's drawing. Despite my confidence in interpreting Earl's use of "just going," I am not as confident in characterizing Earl's (line 16) use of *"expanding throughout the room"* as he continued to talk. This phrase could be describing an understanding of the waves getting larger and covering more space, or could be interpreted as an extension of his talk about the sound waves "just going." I return to this in my analysis of future drawings to see if the notion of "expanding" is picked up by the group.

Reflectivity. Another sound transmission idea explored by the boys during the critique of Kenneth's drawing was *reflectivity.* To do this, I focus on the boys'

use of the term *"bouncing off walls"* within their talk of the drawing. Again, I highlight Floyd's utterance (line 2), *"going around bouncing of walls,"* but this time in order to focus on reflectivity. At this point in the group's conversation, I believe in Floyd was simply identifying that the sound waves were bouncing off the walls in Kenneth's drawing. However, Floyd's use of "bouncing off walls" within the same statement in which he unfavorably described the lines as "going around" will arise again during the discussion of another drawing. In addition, I find Earl's (line 7) joke that the sound "is terrible" to be interesting, especially in relation to the definition of reflection and its impact on the clarity of sound. Within a space of *Signifying,* where the boys continually tease or "crack jokes" about each other's drawings, Earl's banter strikes me as not unlike what may in fact happen to the perception of a sound after it reflects off of a surface. If the situation had been different and I had been trying to teach the boys about properties of sound, I might have utilized Earl's "joke" as a foundation for introducing a more in depth study of sound transmission and the idea of reflection.

Summary. In this section, I have examined the ways the boys talked about and analyzed two sound transmission ideas: 1) *directionality* and 2) the *reflectivity* (see Table 4). The boys' use of phrases such as "just going around" emerged as a contrast to their previous description of directionality as "going everywhere" or "going in all directions." Regarding reflectivity, the terms "bouncing off of walls" emerged as the primary descriptor of this idea. I did not

see any other initial exploration of this idea beyond the language that the boys used to describe the idea.

Table 4

Sound transmission idea discussed the critique of Earl and Kenneth's drawings

Analyzed Drawing	Directionality	Distance Traveled	Reflectivity	Pitch
Earl	•	•		
Kenneth	•		•	•

Student 3: Floyd

"How come it starts off big and gets smaller?" Continuing to Examine Directionality and Introducing the Relationship of Between Distance and Volume

Floyd's drawing (see Figure 26) was the third to be examined.

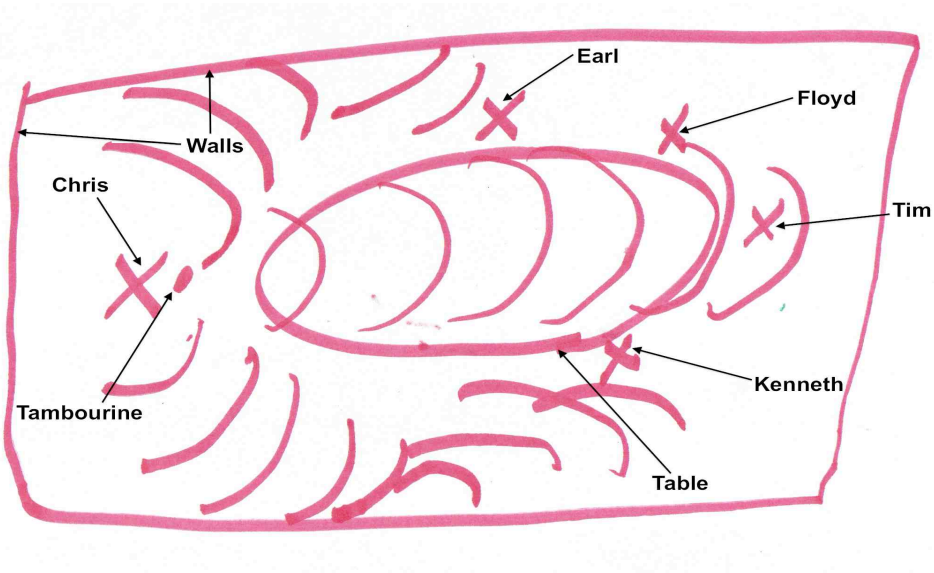

Figure 26. Floyd's 1st drawing representing sound transmission.

The following exchange, prompted as before by me, then unfolded (see Excerpt 4.3):

Excerpt 4.3. What do you all notice about Floyd's drawing?

1. Chris: So, what do you all notice in there [Floyd's drawing]?
2. Kenneth: It's waves going in all directions, how it should be, except straight forward.

[Simultaneous group conversation.]

3. Tim: The waves is bouncing too.
4. Earl: The waves were everywhere, except how in my drawing, the waves are going everywhere except behind them.
5. Chris: Okay. So, should the waves go behind you?
6. Earl: Yeah, because they bounce off the wall. They can just go everywhere.
7. Chris: Okay, anything else? Floyd, they all the same size, so what does that mean?
8. Floyd: Well, I was trying to hurry up. But, I was trying to make the same length that the biggest one. They show how far they went. Like it showed that it got bigger over distance.
9. Chris: So, it get louder, you said?
10. Floyd: Yeah.
11. Earl: I got a question.
12. Chris: Yeah?

13. Earl: Floyd, how come it starts off big and then when it bounces off the wall, it gets smaller?
14. Floyd: Oh, because, it's loud right there [directly surrounding the tambourine]. It's loud when it come from the thing. And then, the reason I did that, I'm about to get all scientific on you. The reason why I did that is from experience. When somebody calling your name from downstairs, it seemed like it's loud when you right there. But when you upstairs, you could barely hear them. And so, that's why our waves are big around the tambourine.
15. Chris: Okay, alright. So, you said that they're the same size before because they get louder as you go along?
16. Floyd: No, they get smaller.
17. Chris: They get smaller, you said?
18. Floyd: Yeah.

In analyzing the boys' conversation regarding Floyd's drawing, I will highlight the group's continued talk about the directionality of sound transmission and the reflectivity of sound waves. In addition, I will trace how the boys' previous talk regarding the distance in which sound waves travel developed into talk about change in volume over distance represented in Floyd's drawing. From a scientific perspective, as sound waves originate from a point source (i.e., the tambourine within this study) and propagate through a space in three dimensions, the waves

become less intense. Whatever energy is created by the wave at the source of the sound is diluted with increasing distance from the source (Parker, 2009).

Directionality. The boys' talk regarding directionality in relation to Floyd's drawing was very similar to the language developed during the group's conversation around Earl's drawing. Again, the boys' use of *"going in all directions"* and *"going everywhere"* emerged as the primary ways of talking about directionality. Initially, Kenneth (line 1) used *"going in all directions"* to describe Floyd's representation of directionality. Kenneth's use of the phrase "going in all directions" was different from his previous descriptions of directionality, as he exclusively used the language of "going everywhere" during the group's previous examination Earl's drawing (line 4 and line 7, Excerpt 4.1). At the end of Kenneth's utterance (line 2), he appeared to be noting a problem when he said: "it's waves going in all directions, *except straight forward."* As a participant in the conversation, however, I think Kenneth is actually accepting Floyd's representation of directionality. After reviewing Kenneth's body language and the tone of his utterance on the videotapes, I interpret Kenneth as meaning, "how it should be, and not just straight forward," again highlighting the idea that the drawing provided an accurate representation of the directionality of sound transmission. To further explore my interpretation, I reviewed Floyd's drawing (see Figure 26) and noticed that his sound waves are illustrated as going forward, to the left, and to the right of the sound producer (noted as the tambourine in Figure 26).

The boys' talk regarding directionality continued with Earl's (Excerpt 4.3, lines 4 and 6) description of sound as "going everywhere, which was similar to the language he used to describe his own drawing (e.g., line 1 and line 4, Excerpt 4.1). In addition, Earl (line 4) focused on Floyd's omission of depicting sound as having the ability to travel behind the sound source. Although Earl utilized the same language to describe directionality of sound, I am curious about his (line 6) combination of "just go everywhere" in the same utterance as "bouncing off the wall" which is associated with the idea of reflectivity. This could simply be a coincidence in his attempt to explore the two ideas, but it is possible that Earl is exploring the idea that Floyd's sound waves are "going everywhere" *because* they bounce off the wall.

Change in Volume Over Distance. While tracking the group's discussion of the relationship between the distance sound waves travel and change in volume, I will also integrate data that exemplifies the linguistic resources that the boys utilized. Initially, Floyd (line 8) highlighted the idea of distance in response to a question regarding the length of his sound waves, by stating, *"They show how far they went."* Following my initial questions (line 7 and line 9) regarding the length of Floyd's sound waves and Floyd's response, Earl (line 13) posed a question that I believe initiated the discussion of the idea of volume changing over distance. First, as a participant in the discussion and fellow *Signifier* with the boys, I saw several possible "meanings" within Earl's question because I recognized his use of elements of indirection. As noted earlier, using elements of

indirection, a speaker (in this case, Earl) alludes to and implies meanings that are rarely made explicit to the listener (in this case, Floyd; Mitchell-Kernan, 1972). Here are the possible meanings I can see in Earl's remark. First, Earl (line 13) could simply be asking Floyd to clarify the meaning he is intending to communicate by changing the length of the sound waves as they travel. Second, he could also be asking for clarification of why the larger sound waves are around the sound producer or why the smaller sound waves are amongst the boys. Third, he could be challenging Floyd's drawing because it does not depict the sound waves as going everywhere throughout the entire room, specifically behind the sound producer, as he previously stated in line 4. However, the final, and most plausible interpretation from my point of view, is that he is using elements of indirection (Mitchell-Kernan, 1972) to challenge Floyd's drawing and the way Floyd represented sound waves bouncing off walls. The mere fact that Earl's utterance (line 13), *"How come it starts off big and then when it bounces off the wall, it gets smaller,"* contained the potential for numerous meanings qualified this linguistic practice as an act of *Signifying,* as previously defined. During the boys' critique of Kenneth's drawing, Floyd (line 2, Excerpt 4.2) commented on Kenneth's depiction of lines that were "going around bouncing off walls." So, I hear Earl's question as a moment of indirection, challenging Floyd to explain what makes his [Floyd's] drawing different from Kenneth's drawing, which Floyd recently commented on. Moreover, I believe that Floyd heard Earl's comment this way too because he quickly constructed a pointed and strong response (line 14):

"Oh, because, it's loud right there [directly surrounding the tambourine]. It's loud when it come from the thing. And then, the reason I did that, I'm about to get all scientific on you. The reason why I did that is from experience. When somebody calling your name from downstairs, it seemed like it's loud when you right there. But when you upstairs, you could barely hear them. And so, that's why our waves are big around the tambourine."

From a linguistic point of view, Floyd's interpretation of and response to Earl's question is as impressive as Earl's production of the question itself because Floyd is required to quickly sort through the various meanings of the question and produce a response that accurately defends his drawing and addresses the question. In this way, Floyd's response (line 14) introduced change in volume into the group's ongoing discussion. Floyd implicitly stated that he was attempting to illustrate how distance impacts the volume at which you hear a sound: the further away you are from the sound producer, the quieter the volume. In line 14, Floyd engaged the group in a moment of braggadocio (Mitchell-Kernan, 1977; Smitherman, 1977), *"I'm about to get all scientific on you."* In this humorous, but pointed utterance, Floyd alerts his listeners to the importance and power of the argument he is about to mount. He does this because he has interpreted Earl's question as a challenge and perceived the need to provide the group with evidence for his understanding that volume decreases the further it travels from the sound source. He called upon his well-honed linguistic skills to answer the question, but also to establish himself as a person with scientific knowledge within the group.

In this moment of humor, *change in volume* was introduced as a fifth idea about sound transmission for the boys to consider in their representations.

Summary. Analyzing the boys' discussion of Floyd's drawing, I recognize that they have continued to explore the idea of directionality (see Table 5). Their language regarding this idea remained fairly stable as they continued to describe sound as "going everywhere" or "going in all directions." In addition, the language and ideas they expressed regarding how sound can reflect, or "bounce off of walls," also remained similar over the analysis of the two previous drawings. Although the conversation of these two ideas remained fairly stable, I want to highlight that Floyd introduced a new way of talking about distance, as he included distance in relation to the sound's volume. Floyd's introduction of this idea was not an individual act, but one that was co-constructed with Earl as they engaged in *Signifying* in order to explore the scientific ideas represented in Floyd's drawing.

Table 5

Sound transmission ideas discussed during the critique of Earl, Kenneth, and Floyd's drawings

Analyzed Drawing	Directionality	Distance Traveled	Reflectivity	Pitch	Change in Volume over Distance
Earl	•	•			
Kenneth	•		•	•	
Floyd	•	•	•		•

Student 4: Tim

"He got stinky lines:" Reinforcing the Group's Description of the Change in Volume

The fourth and final drawing critiqued by the group during this segment was Tim's drawing (see Figure 27).

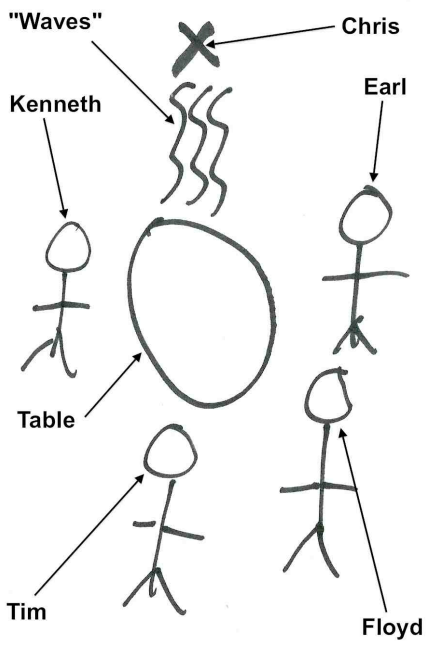

Figure 27. Tim's 1st drawing representing sound transmission.

When Tim's drawing was introduced, the boys burst into laughter as they did with Kenneth's drawing. After the laughter subsided, the following conversation (see Excerpt 4.4) regarding the drawing ensued:

Excerpt 4.4. What do you notice about Tim's drawing?

1. Chris: Okay. What's happening here? [Children burst into group laughter.]
2. Floyd: He [Chris, as the source of sound] got stinky lines on top of him.
3. Chris: You said what now?
4. Floyd: Saying you [Chris, as the sound source] stink.
5. Kenneth: It looks like you [Chris, as the sound source] wasn't playing the volume loud at all, because the waves are going nowhere //

6. Tim: I wasn't finished //
7. Kenneth: About two feet in front of you [Chris, as the sound source].
8. Chris: Oh, so it said they aren't going anywhere except that they're stopping at the table right here?
9. Group: Yeah.
10. Tim: Yeah, I wasn't finished.
11. Chris: Okay.
12. Kenneth: Then why'd you give me the paper?
13. Chris: Okay, got you, alright.
14. Earl: Next time, make the waves more bigger.
15. Kenneth: Not that way.

The idea of change in volume over distance is discussed further as the boys examined Tim's drawing (see Table 6). Kenneth (line 5) showed he was examining Tim's drawing with respect to this idea in his statement, *"It looks like you wasn't playing the volume loud at all, because the waves are going nowhere."* In this statement, Kenneth explicitly acknowledged his focus on volume and provided evidence regarding his understanding of the volume that Tim illustrated by connecting the idea to distance, *"waves are going nowhere."* As Kenneth continued with his analysis (line 7), he may appear to contradict himself by saying "going nowhere" and "about two feet," but instead I think he is emphasizing his meaning through this coupling of terms. I believe he is contrasting Tim's drawing to Earl's drawing (see Figure 22) where sound was

described as “going everywhere” (lines 1 and 4, Excerpt 4.1) and “going pretty far” (line 7, Excerpt 4.1), thus he is combining the focus on directionality and distance. Based on this, I believe the primary idea explored through the discussio of Tim’s drawing was the change of volume over distance (see Table 6).

Also evident in this excerpt are the boys’ uses of *Signifying* acts in order to accomplish several goals simultaneously. Let’s start with the boys’ laughter as Tim’s drawing was introduced. Like their reaction to Kenneth’s drawing, here their laughter was a humorous move to problematize Tim’s drawing. Used in this way, the laughter was an accepted practice that continued as drawings were critiqued throughout the four sessions, as Tim later engaged in similar practices as well. Following their laughter, Floyd (lines 2 and 4) used sarcasm (Mitchell-Kernan, 1977) to critique Tim’s drawing. By describing Tim’s notations as representing stinky lines, Floyd was implicitly questioning, or problematizing, Tim’s use of this notation for sound by stating an opposite or unexpected interpretation of his notations. Although he did not question Tim’s understanding sound transmission, Floyd’s sarcasm highlighted the attention that the boys gave to evaluating what notation they considered appropriate for representing sound and transmission. Kenneth (line 15) expounded upon Tim’s use of this particular notation as he stated, *“not that way”* in relation to how Tim should represent sound in the next drawing. The detail of what notations the boys considered appropriate to use for sound transmission will be further explored in Chapter 5.

By way of concluding the analysis of the discussion regarding Tim’s drawing, I want to point out that he stated several times that he was “not finished”

(line 7 and line 10). I believe that this was Tim's attempt to provide an explanation for why his drawing did not include the level of detail regarding sound transmission that the other boys included. I find Tim's assertion of not being finished interesting because in reviewing the videotape, he was the first boy to complete and submit his drawing. To this, Kenneth presented a sarcastic challenge: He (line 12) also recognized that Tim was the first boy to submit his drawing and asked him, "then why'd you give me the paper?" Here again, we see the boys employing *Signifying* acts as a way to mount their critique, whether they were criticizing how they chose to represent sound transmission on paper or the practices that they engaged while representing sound transmission.

Table 6

Sound transmission ideas discussed during the critique of Earl, Kenneth, Floyd, and Tim's drawings

Analyzed Drawing	Directionality	Distance Traveled	Reflectivity	Pitch	Change in Volume over Distance
Earl	•	•			
Kenneth	•		•	•	
Floyd	•	•	•		•
Tim					•

Student 5: Isaac

"I wasn't drawing it in 3D:" Highlighting Directionality

Isaac was absent for Session One. So, his first drawing was actually produced in Session Two. So, to look at his first drawing, we need to move to Session Two. Session Two of the four-day exploration of sound was designed to further examine the boys' ideas regarding sound waves. Sound waves, and how sound waves behave (e.g., they bounce off of walls, they travel far, they travel through the air, they're going everywhere), had emerged as the primary topic of conversation and debate during Session One; Session Two provided an opportunity to build upon that work. Examination of Isaac's first drawing provides an opportunity to further explore the group's focus on the ideas of sound transmission (see Table 6). The following analysis consists of the presentation and critique of the drawing in Figure 28.

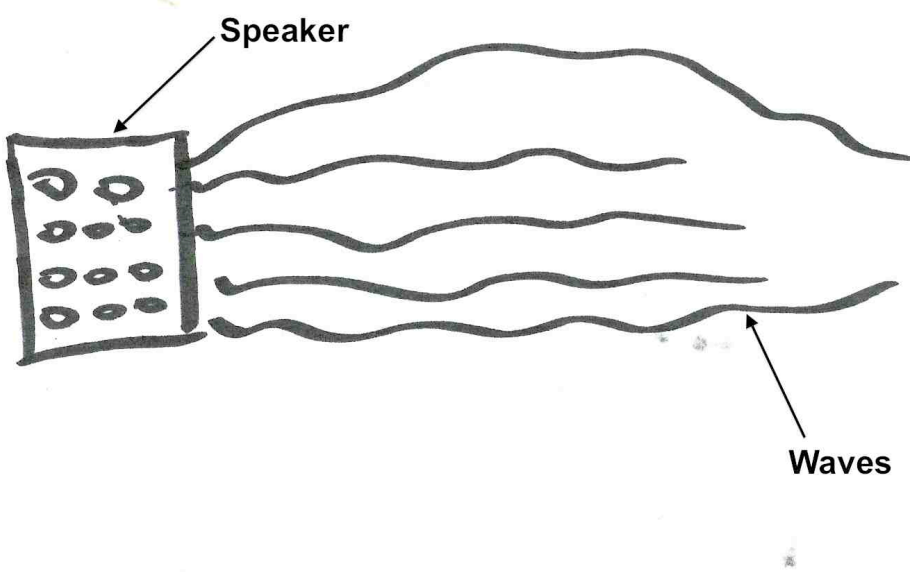

Figure 28. Isaac's 1st drawing representing sound transmission.

I started Session Two by asking the boys what they thought sound waves were and had them draw examples. Following the format of the previous session, the boys then analyzed the drawings. The boys put his drawing in the table and the following conversation ensued (see Excerpt 4.5):

Excerpt 4.5. Critiquing Isaac's Drawing

1. Chris: So, are these all here, are these… so, there are a couple of different ways of showing sound waves, do all these make sense how they're drawn?
2. Earl & Isaac: Yeah.
3. Kenneth: Yeah, but his [Isaac] wave don't go; it only goes straight forward.
4. Chris: What do you mean by that?
5. Kenneth: The sound is only going straight forward instead of all over.
6. Isaac: 'Cause that's the way the speaker is directed //
7. Kenneth: But sound will still //
8. Isaac: But if I was to make it [the speaker] go back further then it [the sound] would go all over the place.
9. Earl: I understand what he's doing. They all the same – they all different waves of sound, but he just made his wavy.
10. Floyd: Naw, man, the ummm [group laughter].
11. Isaac: No man 'cause look, look, this is what I did – I draw a speaker, and you know when like (1.0) ahh say somebody playing the guitar and they plug their guitar up to the speaker, you know it carries sound

but at the same time the speaker vibrates. That's part of its motion because when the speaker vibrates, it send off waves like this [those depicted in his drawing], but if it wasn't to vibrate it would just sending out music. Then it would be something like that so it vibrate and it send out music at the same time.

12. Floyd: Naw, but look at how yours – the speaker only goes one way. That drawing is saying that you were standing right in front of the speaker, the sound would go to you, but if you were standing like //
13. Kenneth: On the side of the speaker //
14. Floyd: Yeah, on the side of the speaker, you couldn't hear the music. The waves is saying it's spreading out all the way around you.
15. Isaac: Yeah, I understand that, but I wasn't drawing it in 3D. I was just making an example.

In this excerpt, I highlight the boys' continued talk regarding the aspect of directionality (see Table 7) and how Isaac's drawing complemented or contrasted their understanding of sound "going everywhere." Kenneth (line 5) read Isaac's representation as contradicting the group's understanding of sound as "going everywhere" or "going in all directions," and described the sound as "straight forward." Kenneth's use of language that established an explicit contradiction to the group's original understanding of directionality, was a common practice during the analysis of these drawings. The primary idea that I want to highlight regarding this excerpt is the difference between Isaac's understanding of the

representation and the rest of the group's understanding. Isaac was not present during Session One when the other group members negotiated and constructed language to describe directionality and an understanding of directionality that informed their representation of the idea. Isaac had the understanding that he was simply making an example (of what is still in question, but he stated that it was just an example; line 15). Thus, this disjunction between Isaac and the rest of the group highlights the kind of collaborative activity the boys engaged in to construct shared understandings of the science of sound, the language regarding this understanding, and the representational practices they used to depict their understanding. This collaborative process and its outcomes are the primary focus of the remaining chapters.

Table 7

Sound transmission ideas discussed during the critique of Earl, Kenneth, Floyd, Tim, and Isaac's drawings

Analyzed Drawing	Directionality	Distance Traveled	Reflectivity	Pitch	Change in Volume over Distance
Earl	•	•			
Kenneth	•		•	•	
Floyd	•	•	•		•
Tim					•
Isaac	•				

Summary

The goal of this chapter was to examine the B-Street boys' talk in order to highlight the intellectual and linguistic resources they used as they engaged in the practice of critiquing drawings. From this analysis, I identified five ideas regarding sound transmission that the boys recognized and explored: *directionality* of sound transmission, the *distance* that sound travels, the *reflectivity* of sound waves, *pitch* of sound waves, and the *change of volume over distance* (see Table 7). From these five ideas, *directionality* and the *change in volume over distance* emerged as the primary themes for the group's discussions in subsequent sessions and will be further discussed in Chapter 5. In determining which ideas were "primary," I looked at Table 7 to determine the frequency with which the ideas were examined across the drawings. *Directionality* was highlighted in four of the five drawings, while distance traveled, reflectivity, and *change in volume* were explicitly highlighted in two of the five drawings. Pitch was highlighted in one drawing. In the remaining chapters, I focus on directionality because it was represented with the greatest frequency and change in volume because I believe that the talk concerning distance travelled developed into talk around the change in volume, increasing its frequency. Let me explain further.

The boys' *directionality* talk remained fairly stable throughout the discussions of the five drawings. Starting with their interpretation of Earl's drawing, the boys constructed a shared language for describing *directionality,* including "going everywhere" and "going in all directions." In contrast, when

drawings were deemed as inaccurately representing *directionality,* the boys contrasted this shared language by developing and utilizing opposing language, such as, "just going" or "straight forward." In the context of critiquing drawings that represent sound transmission, the boys' development of a localized way of talking about *directionality* was instrumental in the group's emergent ideas regarding how to represent sound transmission.

The boys' talk regarding the *change in volume over distance* was also collectively constructed through opportunities to engage in the group critique of five drawings. I argue that talk regarding this idea developed from the group's original focus on the *distance* in which sound travels. For example, Kenneth first described the idea of *distance* by saying that the sound waves "go pretty far;" his view of this continued to develop into (line 7, Excerpt 4.1), *change in volume over distance* as he described Tim's drawing (see Figure 27) by saying, "It looks like you wasn't playing the volume loud at all, because the waves are going nowhere" (line 5, Excerpt 4.4). In this way, the type of talk exemplified by Kenneth displays how the practice of critiquing representations also provided the boys with opportunities to further explore their understanding of the scientific ideas. In this instance, the boys probed their understanding of the relationship between volume and distance, and how to represent it in a drawing.

Lastly, this chapter highlighted how the boys' drawings functioned within the practice of critique. Each individual's drawing played a unique and important role in the helping to further discussion and exploration sound transmission ideas. Earl's (see Figure 22) drawing served as the initial drawing for critique and

offered the boys the opportunity to "read" the drawing and identify important ideas of sound transmission to possibly focus on during the interpretation of future drawings. This is important to note because the discourse about the remaining four drawings (Floyd's, Kenneth's, Tim's, and Isaac's) developed from the shared ways of talking about the drawings that preceded them. Recognizing how the boys' developing talk and understanding of these ideas was important, the next chapter will identify and summarize how the emergent representational criteria developed and impacted the each boy's second drawing.

In addition to highlighting the sound transmission ideas that emerged during the boys' critique of their initial drawings, this chapter also identified how the boys' acts of *Signifying* functioned during their exploration of these science ideas and ways to represent these ideas. They used practices of indirection/innuendo and sarcasm/irony to problematize a variety of aspects of their drawings (i.e., the notation used, the accuracy of the drawing) and of the assertions they made about sound and one another's drawings. I have tried to show how the boys were unwilling to accept assumed meanings of drawings or assertions, and used *Signifying* elements to complicate and explore the possible meanings of emerging ideas. For example, while examining Floyd's drawing (see Figure 26), Earl (line 13, Excerpt 4.3) incorporated elements of indirection/innuendo as he challenged Floyd's representation of decreasing the length of the sound waves. By challenging Floyd's use of the notation, Earl encouraged the further unpacking of what this representation might mean. Laughter also functioned as an act of *Signifying.* As we saw, the entire group

erupted into laughter upon the presentation of Kenneth (see Figure 24) and Tim's (see Figure 27) drawings. I believe that these group approved acts of *sarcasm,* likewise, encouraged opportunities to further explore the meanings and the ways in which sound transmission was represented in these drawings. Thus, the boys marshaled the community-based practice of *Signifying* as part and parcel of critiquing representations and further exploring the various ideas about sound transmission that emerged.

CHAPTER 5:

REPRESENTING THE IDEAS OF SOUND TRANSMISSION

The previous chapter featured the boys' use of *Signifying* as they explored the following sound transmission ideas and the drawings that represented them: *a) directionality, b) distance, c) reflectivity, d) pitch, and e) change in volume over distance.* The boys' engagement with these ideas was situated in their practice of critiquing each other's drawings from Session One for their effectiveness in representing the aforementioned ideas. In this chapter, I build upon these previous findings to explore the following research question, *what ideas, or aspects, of sound transmission do the B-Street boys collectively explore while producing, interpreting, and critiquing invented representations of sound transmission?* For this analysis, I focus on the ideas of *reflectivity, directionality, and change in volume over distance* because, *pitch* was not carried forward beyond the boys' first drawings of Session One, and their consideration of distance merged with their consideration of volume, and is represented in my analysis of *change in volume over distance*.

Using an approach that focuses on the boys' discursive practices (Enyedy, 2005; Gee, 1999) and an examination of their drawings (diSessa, 2002), I focus this analysis on the boys' emerging understanding of these sound transmission ideas. Specifically, I highlight the contexts in which each of these ideas were explored, as well as how the boys explored these ideas through their drawings and interpretations of these drawings. I emphasize instances during the four-day exploration in which each of these ideas was deemed significant enough to focus

upon, even though these ideas may have appeared and disappeared at other times during the exploration. Although each of the ideas were introduced and briefly discussed during the critique session of the group's first drawings, I claim that the boys' focus on each of these three ideas was effected by the specific context or drawing task they engaged in during the rest of the exploration.

Specifically, the analysis in this chapter examines both the group and self-analysis of the boys' other drawings, produced in the remainder of Session One through Session Four. Although I analyzed all of the boys' drawings, I will focus primarily on the contrast between the boys' first and second drawings from Session One to investigate the influence the context of the task may have had on the ideas that the boys emphasized in their drawings. Although the drawings from Session One are the primary focus of the chapter, I also incorporate data from the remaining three sessions in order to provide additional evidence for the assertions I make within this section. Finally the drawings from four of the five boys (Earl, Floyd, Kenneth, and Tim) are the focus of my analysis. I focus on these four boys because (unlike Isaac who was absent for Session One), they all participated in the shared experience of Task Two during Session One and I believe that this shared experience, which will be detailed in a later subsection, played a prominent role in the emergence, or non-emergence, of the ways they translated their ideas about sound transmission into representations of these ideas. Although my primary focus is on these four boys, I will also discuss the drawings of the fifth boy, Isaac, as makes sense for my analytic purposes.

My analysis revealed that the boys took up each of the ideas of reflectivity, directionality, and change in volume over distance differently in their second drawing, as well as in future drawings. During the discussions around the boys' second drawings, the idea of *reflectivity* was briefly discussed, but not explicitly represented, and the data suggests that it was not taken up again throughout the four-day exploration. The idea of *directionality* became a very important idea to discuss and explicitly represent during the remainder of Session One, but appeared to lose some of its explicit focus during Sessions Two through Four. The idea of *change in volume over distance* emerged as an important idea that was discussed and explicitly represented during the entire four-day exploration. The following subsections are organized to describe the boys' relative emphasis on each of these ideas during the remaining drawings tasks: focusing on *reflectivity,* focusing on *directionality,* and focusing on *change in volume over distance.* Although more than one idea may appear in any given drawing or during a group discussion, my analysis tracks the specific idea being highlighted. I begin by providing a description of Task Two during Session One.

Description of Task Two During Session One

Following the group critiques of the boys' first drawings during Session One (see Chapter 4), the boys were introduced to a new experience with the sound from a tambourine. Rather than listening to sound from within the same room as the tambourine, the boys listened to the tambourine's sound from an adjacent room. A solid wall, with an open doorway, separated the two rooms. After

experiencing the sound, the boys discussed how they thought the sound reached their ears. Following these discussions, the boys produced their second drawing, intended to represent this experience. Each boy was asked to provide the group with a self-analysis of the differences between his first two drawings. Then the group discussed this. In the following section, I analyze how and why I think the idea of *reflectivity* did not develop into an idea that the boys explicitly represented in drawing two of Session One, or in any future drawings.

Focusing on Reflectivity.

During the boys' critique session of the boys' first drawings, the idea of *reflectivity* became a topic of discussion during the examinations of both Kenneth's (see Figure 24) and Floyd's (see Figure 26) drawings (see Table 7). In each of their initial drawings, they presented and described sound waves as "bouncing off walls" within the same room. For example, when Kenneth's drawing (see Figure 24) was presented to the group, Floyd said "I don't know [what's happening there]. There's some lines going around bouncing off walls." (Line 2, Excerpt 4.2) In addition, after Floyd's first drawing (see Figure 26), Tim stated, "The waves is bouncing too." In contrast neither Kenneth nor Floyd included representations of sound waves bouncing off walls in their second drawing. This finding led me to want to further investigate why reflectivity was dropped out of the boys' drawings and talk.

Why did Kenneth and Floyd decide to not represent the idea of reflection in their second drawings? Specifically, I argue that the experience with listening

to sound from an adjacent room played a central role in this decision. Enyedy (2005) defined representation as "the act of highlighting aspects of our experiences and communicating them to others and ourselves" (p. 427). After the boys experienced sound from an adjacent room, they were challenged to "highlight aspects of their experience" through their second drawing. I begin the analysis of reflectivity by focusing on Kenneth's second drawing (see Figure 29) and his subsequent self-analysis (see Excerpt 5.1).

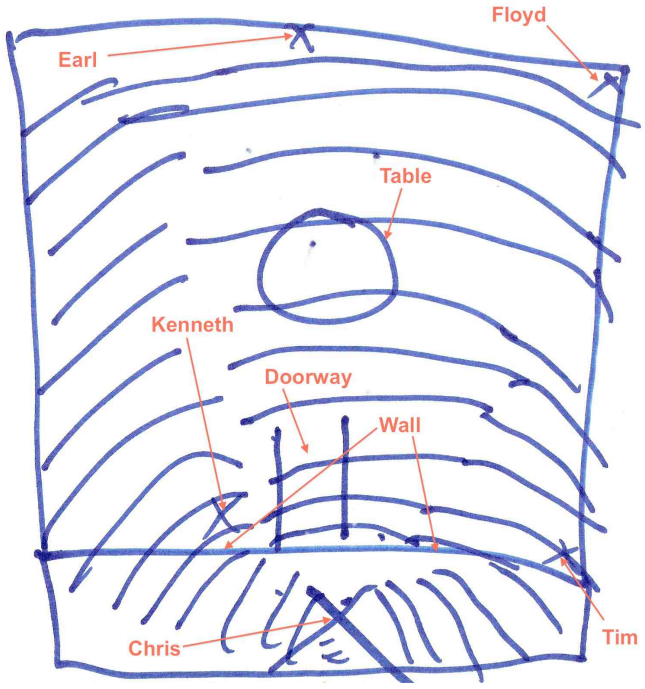

Figure 29. Kenneth's 2nd drawing of sound transmission.

Following the presentation of his second drawing, Kenneth provided the following self-analysis:

Excerpt 5.1. Kenneth's self-analysis of his first two drawings

> The waves [in his 2nd drawing, see Figure 29] just travel, instead of bouncing off the wall [as depicted in his 1st drawing, see Figure 24].

Unpacking Kenneth's statement, I see that he explicitly said that the sound waves in his second drawing "just travel instead of bouncing off the wall." I maintain that in his second drawing, Kenneth was representing the second experience with sound, from Task Two, as opposed to his experience with sound during Task One. Because the context of Task Two includes experiences with the tambourine's sound from an adjacent room, which by definition includes the presence of walls, I contend that Kenneth was representing phenomenon of hearing the sound through walls. So, I believe that Task Two attuned Kenneth's attention to the particulars of sound transmission *between* two rooms, in contrast to Task One, which attuned his attention to the particulars of sound transmission *within* the same room. Comparing Kenneth' drawings in this way highlights the idea that rather than having a single, fixed understanding of a complex phenomenon like sound, children have a "web of ideas" (Gustafson, 1991) to call on and that the question or scenario could play a critical role in their responses.

Floyd's second drawing (see Figure 30) also omitted the representation of sound *"bouncing off walls."*

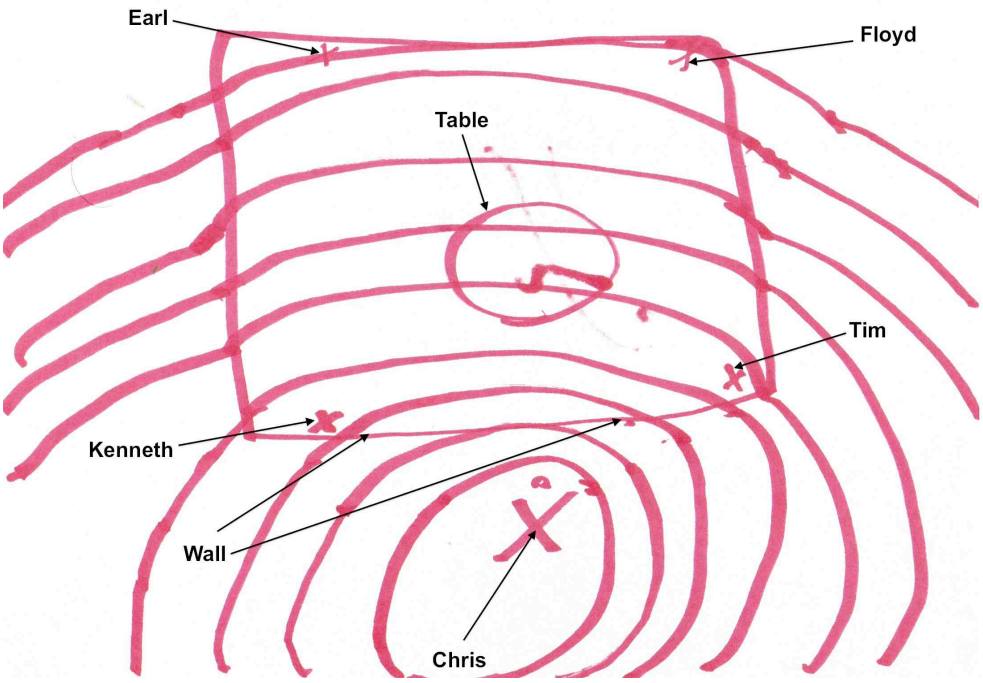

Figure 30. Floyd's 2nd drawing of sound transmission.

He provided the following self-analysis (see Excerpt 5.2), comparing of his first and second drawing:

> *Excerpt 5.2. Floyd's self-analysis of his first two drawings*
>
> And they [the sound waves] bouncing off the walls in my first one. But, in my second one, I just made it [the sound] go everywhere because I think you could hear the noise outside the room, it's just not contained in the room.

Here too, I believe that the context for Task Two played an important role in Floyd's decision to omit representations that depict sound waves as bouncing off walls. Specifically, I focus on Floyd's last sentence (Excerpt 5.2), *"But, in my second one, I just made it go everywhere because I think you could hear the noise*

outside the room, it's just not contained in the room." Here, I believe Floyd is representing his "experience" in Task Two of hearing the noise from the adjacent room. He is suggesting that by incorporating representations of sound waves as bouncing off the walls as he had in his first drawing, he believed that he would be implying that sound was "contained" in the room, thus not allowing the group to hear it from the other room and not accurately representing their experience.

Examining the Floyd and Kenneth's subsequent eight drawings, spanning Sessions One through Four, I found that none incorporated *reflectivity.* This led me to further examine possible differences that may have existed between in the tasks I posed as the basis for Drawing One in Session One and the other drawing tasks posed during the rest of the four-day exploration. The contexts for each of the subsequent eight drawings entailed experiencing sound transmission from an adjacent space (e.g., a sound from an adjacent room, a sound from outside the house, or a sound from upstairs). Provided with other contexts or scenarios, the boys might have continued to incorporate a focus on *reflectivity,* but within the exploration of sound as I designed it, reflectivity did not emerge as an idea that they explicitly represented.

This finding has implications for how the field describes, categorizes, and identifies children's "conceptions" of sound transmission. Treagust et al. (2001) called for the use of a variety of opportunities for children to provide their ideas, including group or small-group talk, writing, and drawing. These opportunities provide us with a broader range of children's ideas regarding science topics. If I had analyzed either of Kenneth's or Floyd's first two drawings in isolation in

order to describe their understandings, my analysis would have been misleading. For example, while analyzing Drawing Two of either boy, I may have rightfully concluded that he knew that sound reflects off surfaces. Instead, with only two examples, I believe that the ideas represented were impacted by the contexts of the tasks, one experiencing sound within the same room and one experiencing sound from adjacent rooms and through solid walls. In addition to identifying *reflectivity* as an idea that was not explicitly represented in most of the boy's drawings, this subsection also highlights the contributions that the use of varied contexts, experiences, and guiding questions could provide to our understanding of children's ideas regarding sound.

Focusing on Directionality.

During their critique of the boys' first drawings, the idea of *directionality* was discussed during four of the five analyzed drawings (see Table 7). Because of the frequency with which it was discussed, it was not surprising that *directionality* emerged as an important idea in their subsequent drawings. During their critiques of drawing one, the boys constructed a shared understanding that sound waves should be represented as "going everywhere" and/or "going in all directions." The most explored aspect of this idea of sound "going everywhere" or "going in all directions" was the boys' representation of sound having the ability to also go behind the source of sound. For example, while observing Floyd's first drawing (see Figure 26), Kenneth expressed (line 2, Excerpt 4.3), "its waves going in all

directions; how it should be." Kenneth's explicit use of *"how it should be"* exemplifies the emergence of *directionality* as a key criterion for future drawings.

To explore how the boys addressed the idea of *directionality* in this section, I will focus on Floyd's second drawing (see Figure 30). Floyd's drawing was selected because it was representative of the ways the boys represented directionality in general and because he explicitly addressed the idea of *directionality* during his critique of his first two drawings. In addition to the boys' critique of Floyd's second drawing, I also highlight portions of Earl's first and second drawings as further evidence that the boys continued to explicitly represent *directionality* beyond drawing one in Session One. I gathered evidence from Earl's drawings by utilizing an interpretive analysis only (Roth, 1996), as such I interpret meanings from the two drawings themselves and do not use Earl's verbal description as additional convergent data.

After the group's completion of their second drawing during Session One, I asked, "so, did anybody's drawing the second time – was it different than the first drawing? How is yours different, Floyd?" Floyd's response (see Excerpt 5.3) was:

> *Excerpt 5.3. Floyd's description of how his two drawings differed*
>
> Because, at first [in his 1st drawing, also Figure 26] I made it seem like air wasn't surrounding you [the sound source]. The center of the waves wasn't surrounding you. And they was bouncing off the walls in my first one. But in my second one, I just made it go

everywhere, because I think you could hear the noise outside of the room too. It's just not contained in the room….

First, Floyd was initially singled out because he just happened to be the first boy questioned. Following Floyd's drawing, each of the other boys were also questioned regarding their first and second drawings. In this excerpt, I focus on two of Floyd's statements where I believe he was focusing on the idea of *directionality.* First, I interpret Floyd's description of *"the center of the waves wasn't surrounding you [i.e., the sound source],"*as referencing a focus on *directionality.* If the waves were not "surrounding" the source of sound, then sound would not be represented as traveling in all directions, as Floyd previously pointed out about his drawing (see Line 25, Excerpt 4.1). During the previous analysis of his drawing, Floyd stated, "Now that I talk and think about it, I don't think mine was [correct] either. Seeing that sound travels everywhere, there should be a wave everywhere," which I currently associate with his use of "surrounding." Next, I also highlight Floyd's statement, *"But in my second one, I just made it [the sound wave] go everywhere."* When this statement is considered in relation to the language that the boys developed regarding *directionality* during the critique of the first drawing, "going everywhere" and "going in all directions," I interpret Floyd's emphasis on the idea of *directionality.*

In addition to highlighting Floyd's drawings and comments, I include an analysis of elements within Earl's first two drawings that suggest that he also focused on the idea of *directionality.* Although Earl did not articulate an explicit

reference to *directionality* during his self-analysis, I maintain that it emerged as an area of emphasis within his drawing. My interpretation derives from Earl's representation of sound waves around the sound producer in his first two drawings (see Figure 31).

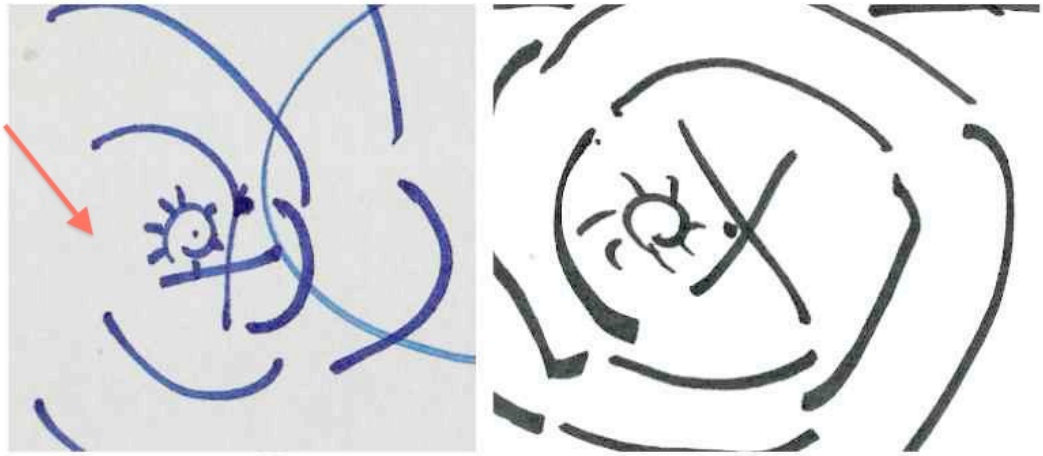

Figure 31. Highlighting the "missing" sound wave in Earl's first drawing (A) and the complete set of sound waves in his second (B) drawing.

In Earl's first drawing (see Figure 31, Illustration A), he did not represent the sound waves as "going everywhere" or "going in all directions," as there is an area around the sound producer that does not include sound waves (as represented by the red arrow in Figure 31, Illustration A). The other boys also interpreted Earl's first drawing as I did, as Floyd stated, "Seeing as though sound travels everywhere, there should be a wave everywhere" (Line 25, Excerpt 4.1). In his second drawing, however, (see Figure 31, Illustration B), Earl represented the sound waves as "going in all directions" or surrounding the source of the sound. Thus, although Earl did not explicitly address *directionality* as a focus of his

second drawing during his self-critique, it clearly played an important role in how he represented sound waves in relation to the sound producer.

I argue that *directionality* emerged as an idea that was important to explicitly represent during the remainder of Session One through the social construction of knowledge because the boys collaboratively developed a shared understanding that sound waves should be represented as "going everywhere" or "going in all directions" during the critique of drawing One in Session One. Although here I have only highlight Floyd and Earl's second drawings, Kenneth and Isaac's second drawings displayed similar aspects thus there was a pattern across all the boys' drawings. I presented data from Floyd and Earl because they illustrate this clearly. As the group produced their third and fourth drawings during Session One, similar patterns of "surrounding" the sound producer were evident in their drawings. As we can see, for example, in Earl's third drawing (see Figure 32), he continued to depict sound waves surrounding the source of sound.

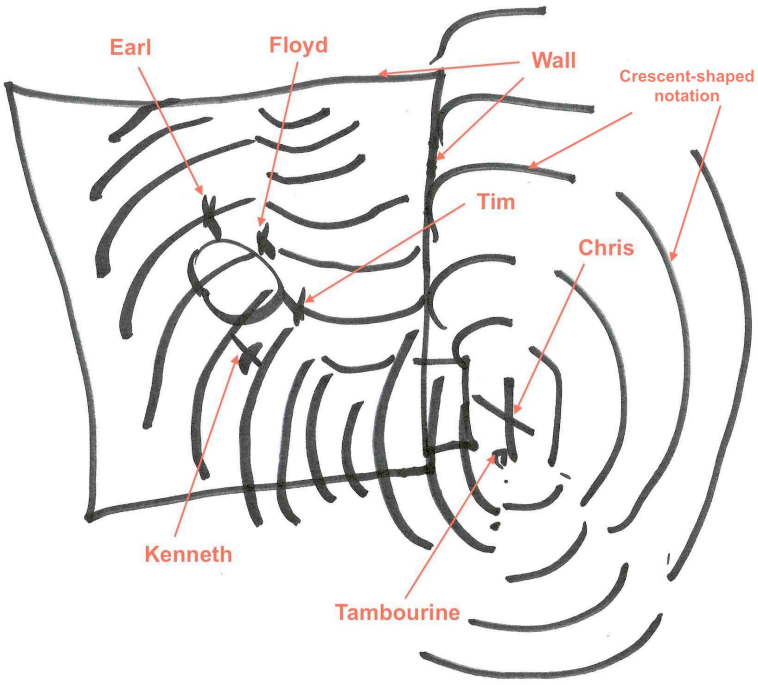

Figure 32. Earl's 3rd representation of sound transmission.

Interestingly, however, the emergence of *directionality's* as a key idea in Session One, it did not continue to be salient in the drawings completed during Sessions Two through Four. For instance, Isaac's drawing (see Figure 33) from Session Three is representative of the boys' drawings during Sessions Two through Four. In this drawing, Isaac did not represent sound waves as "surrounding" or going in all directions around the sound producers, the car outside and the television in an adjacent room.

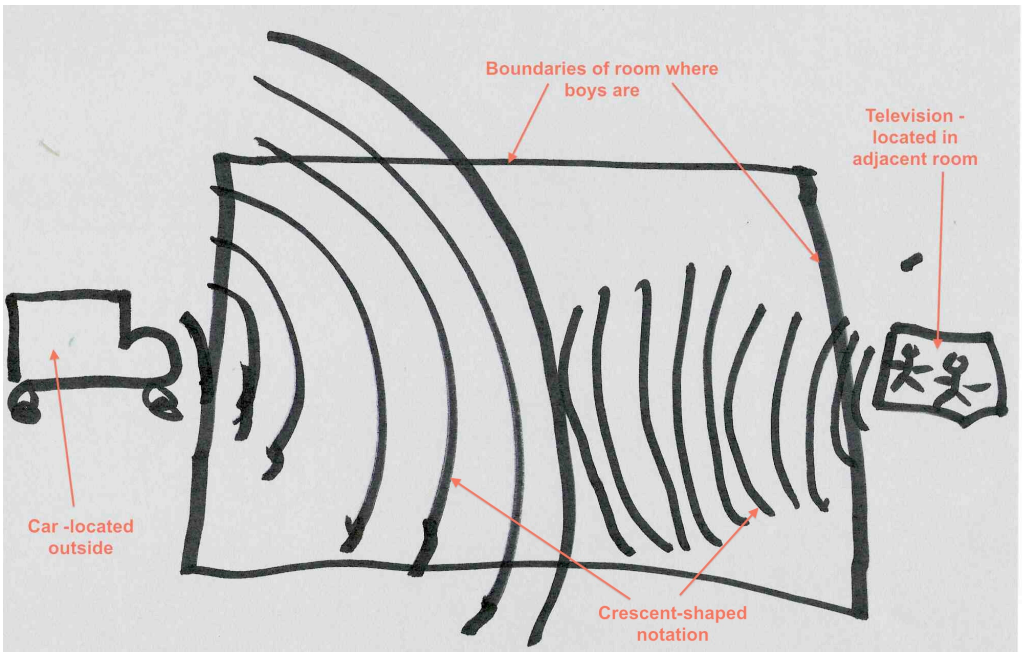

Figure 33. Isaac's 4th representation of sound transmission.

Even though the boys did not explicitly and consistently represent sound waves as omnidirectional in their drawings from Session Two through Four, I found it very interesting that the idea seemed to appear sporadically during the remaining three sessions. For example, when Isaac's first drawing (see Figure 28) from Session Two was analyzed, the boys criticized it heavily for representing sound as "only going straight forward instead of all over" (Line 5, Excerpt 4.5). Thus, I maintain that *directionality* remained an idea that the boys could identify and critique, it was not explicitly visible in the group's drawings.

The boys' representation of *directionality* with only crescent-shaped notations (e.g., see Figure 22 and Figure 26), to then using crescent-shaped notations and circles (e.g., see Figure 31 and Figure 32), and then back to crescent-shaped notations only (e.g., see Figure 33) prompted me to consider

several hypotheses regarding how and why representing *directionality* evolved in this way. First, I believe that the circle is dropped from the drawings after Session One because the boys developed a shared understanding that the crescent-shaped notations implicitly show *directionality.* The requirement of sound being represented as "going everywhere" or "going in all directions" was not a contested idea, so much so that the remaining drawings of Session One depicted sound as traveling in "all directions." Thus, the boys may have determined the crescent-shaped notations were sufficient for the group's understanding of *directionality.* Next, as discussed earlier, I believe that the task context, or the particular questions I posed to the boys attuned their attention to some aspects of sound transmission. The context for Session Three focused on representing how sounds from a car outside the house and a television in an adjacent room get to them [the boys] (see Figure 38). Additionally, in Session Four the boys were asked to represent both a loud and a quiet sound, to represent a sound lasting 1 minute and 30 minutes, and a sound traveling through a theatre curtain. I believe that in addition to having constructed a shared meaning of the crescent-shaped notation, the boys also modified their representations in order to accommodate the aspects of sound transmission that were highlighted in the tasks.

What do I see as the relevance of these findings? I contend that the methodologies that we use in identifying children's conceptions of scientific ideas are important to consider. In this subsection, if I had simply analyzed the boys' drawings from Sessions Two through Four, I might have concluded that they did not think that sound is omnidirectional. When placing the boys in a variety of

scenarios with varying questions for emphasis, the findings suggest that the boys do believe in the omnidirectional feature of sound and ways to represent this idea.

Focusing on the Change in Volume Over Distance. The idea of representing sound's changing volume over distance was first discussed (see Table 7) during the group's analysis of Floyd's first drawing (see Figure 26). Despite its inception during the analysis of the third drawing in Session One, *the change in volume over distance* emerged as an idea that continuously came up during the production and critique of future drawings. During the critique of Floyd's first drawing, Earl (line 13, Excerpt 4.3) asked Floyd why he represented the sound waves as getting smaller after bouncing off the wall. Floyd's response (line 14, Excerpt 4.3) indicated that he was attempting to focus the group's attention on the relationship between volume and distance. Once this idea was introduced to the group, it was later taken up during the analysis of Tim's drawing (see Figure 27). Analyzing Tim's drawing, Kenneth (Excerpt 5.4) stated:

> *Excerpt 5.4. Kenneth's interpretation of Tim's drawing*
>
> It looks like you [Chris, as the sound producer] wasn't playing the volume loud at all, because the waves are going nowhere.

Thus, Kenneth produced an explicit connection of this idea with Tim's drawing and continued the process of explicitly recognizing the representation of this idea within the boys' drawings.

In this subsection, I examine the talk regarding Tim and Floyd's second drawings and illustrate again how the *change in volume* emerged as an idea explicitly addressed by the group. These two drawings were selected because of the explicit references to the change in volume during the group's discussion of the drawings. The examination of the importance the group gives to the change in volume will begin with Tim's second drawing (see Figure 39).

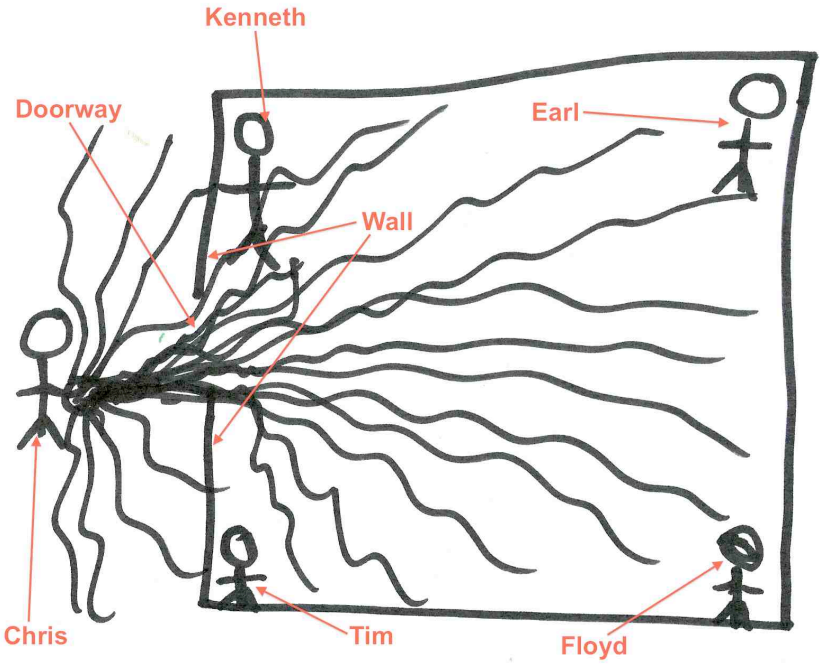

Figure 34. Tim's 2nd representation of sound transmission.

During a general viewing of the boys' drawings, Kenneth (see Excerpt 5.5) interrupted the group conversation to make the following observation of Tim's drawing:

Excerpt 5.5. Kenneth's initial observation of Tim's second drawing

> Well, I don't really understand his because you can't tell where it [the sound] gets higher or lower [volume] or further or closer away.

Kenneth's observation illustrates the importance of representing the *change in volume over distance.* He explicitly highlighted that he could not read if the drawing was representing the sound getting louder or quieter, described as "higher and lower" by Kenneth. Although I cannot definitely state what the purpose of Kenneth's statement was, I also found it interesting that he attempted to incorporate the relationship between volume and distance by stating "further or closer away." As the group had continued to examine and discuss other drawings, Kenneth (Excerpt 5.6) again interrupted the conversation to express another observation:

Excerpt 5.6. Kenneth's second observation of Tim's second drawing

> I just noticed that now I could tell when they [the sound waves] get higher or lower [volume]. Because if you look at it [the drawing], the lines [the sound waves] are closer together. And as they get further [from the sound producer], they spread out.

In this excerpt, Kenneth has maintained his focus on the *change in volume over distance* and how Tim has chosen to represent this idea. Although I later found out that Tim quietly communicated the meaning of his representation to Kenneth, it's important to note that the two boys were engaged in a side conversation

regarding the effectiveness of Tim representing the idea. Kenneth's explicit reference to not being able to interpret Tim's drawing for its representation of *change in volume over distance* is representative of the group's focus on the idea.

In another example, Floyd (Excerpt 5.7) also explicitly recognized his focus on the *change in volume* while describing his second drawing (see Figure 30).

Excerpt 5.7. Floyd's references to the change in volume in his second drawing

> That's why the ones [the sound waves] outside the room is like the biggest. Because, like I said, the bigger they are, the less that you can hear them. And once you get too far, you can't hear them.

In this excerpt, Floyd made an explicit reference to the relationship between volume and distance in his drawing, *"the bigger they are, the less that you can hear them. And once you get too far, you can't hear them."* In order to address this idea, Floyd utilized the increasing size of his notations to represent decreasing volume.

When the boys' remaining drawings were examined, I found that they explored a variety of representational elements in order to represent the change in volume over distance. In the provided examples, Tim (see Figure 34) used compactness, or how close or dense the sound waves were in order to illustrate the sound's volume getting quieter. When the sound waves are closer together, as they are immediately at the sound producer, it is supposed to represent the loudest

sound. As the waves "spread" out, they become less dense, thus representing a decreasing volume as the sound waves travel. Additionally, Floyd (see Figure 30) used the length of the notations to represent change in volume. As the sound waves increased in length, it represented a decrease in the sound's volume. The range of representational elements that the boys utilized to represent this idea will be further explored in Chapter 6, but the important finding in this subsection is that the idea of the *change in volume over distance* emerged as an important idea to explicitly represent within the group.

Summary

The goal of this chapter was to illustrate how the ideas discussed during the boys' critique of their first drawings were further explored during the remainder of the four-day exploration. The misconceptions literature in science education often describes children as either having knowledge or not having knowledge regarding various scientific phenomena. Based on the findings from this chapter, I argue that we, as science education researchers, need to take greater care in identifying and describing children's "knowledge." For example, I found that the idea of *reflectivity* was addressed only during one of the group's 11 total drawings. If I had utilized a research methodology based in a misconceptions framework, I may have described them as not knowing that sound can reflect off of various surfaces. Similarly, the idea of *directionality* was explicitly taken up by the boys during Session One, but disappeared during the remaining three sessions.

These findings prompt me to want to further explore the relationships amongst representational tasks and the ideas that students focused on during those tasks.

After the critique of each boy's drawings, four of the five boys chose to use the crescent-shaped notation (Eshach & Schwartz, 2006) to represent the various aspects of sound transmission. Although most of the boys adopted the crescent-shaped notation, its specific use and appropriation varied among them. This is particularly evident as they discuss and debate the multiple meanings that they associate with the change in length of the crescents; that is, for some the increase in length indicated the volume was increasing and for others that the volume was decreasing. This will be explored further in the next chapter, as I specifically examine the representational elements that the boys used to represent the change in volume over distance.

CHAPTER 6:

CONSTRUCTIVE RESOURCES IN REPRESENTING CHANGE IN VOLUME OVER DISTANCE

The previous chapter examined and identified the sound transmission ideas that emerged during the B-Street boys' production and critique of drawings representing sound transmission. In this chapter, I take a closer look at how the boys handled representing the sound transmission idea of *change in volume over distance.* The idea of *change in volume over distance* is used describe the process in which sound waves, emanating from a point source of sound, become less intense as they move out spherically from the sound producer (Parker, 2009). Therefore, the dynamic relationship between volume and distance is at the core of this idea. Specifically, this chapter addresses a variation of my third and final research question, *what is the range of representational elements that the boys utilize while representing the sound transmission idea, the change in volume over distance?*

Using Sherin's (2000) identification of children's modification of line segments and temporal sequencing as constructive resources, I explore the B-Street boys' use of various representational elements while modifying the crescent-shaped notation. Initially, I describe the process by which the crescent-shaped notation became the agreed upon notation for representing sound/sound waves. Along with this, I look into the heterogeneous ways that the boys modified the "basic" crescent-shaped notation (see Figure 35), using one or a combination of the following representational elements: *a) line weight / line type, b)*

compactness of sound waves, and *c) change in the length of crescents (i.e., increasing or decreasing length).* My analysis draws on the drawings of all five boys' over the duration of the four-day exploration of sound transmission, as well as the group and individual interpretations of these drawings.

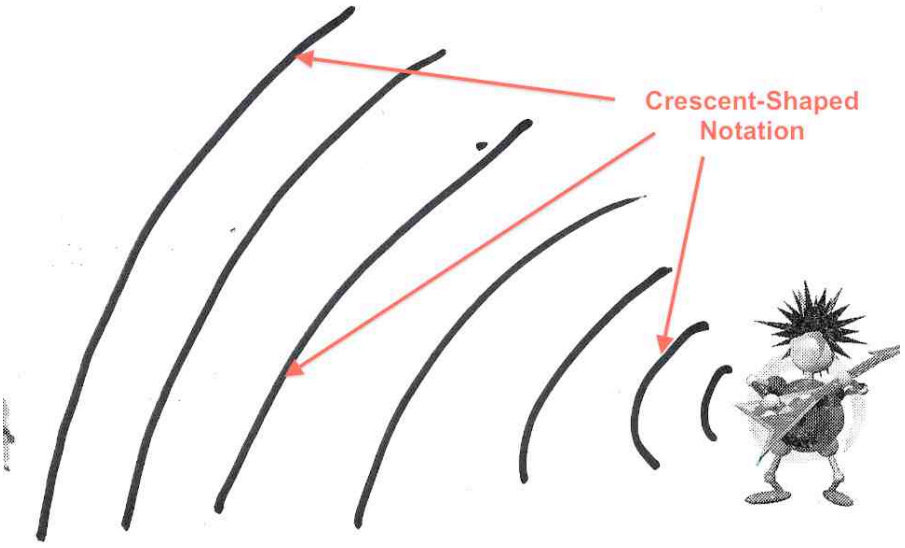

Figure 35. A representative example of the crescent-shaped notation (created by Earl, Pre-Interview).

Initial Development of the Crescent Shaped Notation

During my analysis of the boys' first and second drawings from Session One, it became evident that their use of the crescent-shape (e.g., see Figure 35 for an example) emerged as the most popular notation for representing sound/sound waves. Two of the five first drawings produced by each of the boys incorporated this notation. Following the analysis and critique of the initial five drawings, four of the five boys' second drawings utilized the crescent-shaped notation. These four boys, Earl, Floyd, Kenneth, and Isaac, maintained the use of the notation throughout the entire four-day exploration of sound. The fifth boy, Tim, modified

the notation used in his first drawing (see Figure 27), but did not incorporate the crescent-shaped notations. Instead, Tim maintained the use of a "wavy-like" notation to represent sound waves (see Figure 34).

To begin with, I focus on Kenneth (see Figure 29) and Tim's (see Figure 34) second drawings because they are two of the three boys who did not originally utilize the crescent-shaped notation in their first drawing. Although Kenneth later adopted the use of the crescents, Tim alone used an alternative notation throughout the four-day exploration.

During a self-critique of his first two drawings, Kenneth (see Excerpt 6.1) focused on his use of a different notation for representing sound waves.

Excerpt 6.1. Analyzing Kenneth's first two drawings

1. Chris: So, how did your drawing change?
2. Kenneth: Because, that [his second drawing, see Figure 34] seems more appropriate or better way to do it.
3. Chris: Why is that?
4. Kenneth: Like, it's easier to understand than that one [his first drawing, see Figure 28] was.
5. Chris: Okay, so what is this [Kenneth's second drawing, see Figure 34] showing better than this [Kenneth's first drawing, see Figure 28] one?
6. Kenneth: The waves.

In this excerpt, Kenneth stated that he thinks the "waves," or the crescent-shaped notation, would be "easier to understand" than the notation he utilized in his first drawing. I contend that the waves may have been easier for Kenneth to understand, but, as will become evident later in this chapter, the use of the notations still required the construction of their meaning within the rest of the group. Despite the need to construct their meaning, the crescent-shaped notation still was accepted within this group of boys.

In another excerpt, Kenneth and Earl (see Excerpt 5.9) highlight the notations that Tim used in his second drawing (see Figure 39):

Excerpt 6.2. Kenneth and Earl's critique of Tim's 2nd drawing

1. Kenneth: Well, I don't really understand his [Tim's drawing, see Figure 39] because you can't tell where it [the volume] gets higher or lower [the volume] or further or closer away.
2. Chris: Okay.
3. Kenneth: It would be easier to understand if you had it going //
4. Tim: They stayed the same.
5. Earl: And lines like ours.

Earl (line 5) explicitly suggested that Tim's line would be "easier to understand" if they looked like ours (i.e., like crescents). By this time, the other three boys (Floyd, Kenneth, and Earl) were all utilizing the crescent-shaped notation. So, when Earl (line 5) said "lines like ours," he was referring to the crescent-shaped notation. In addition, while analyzing the videotape of this exchange, I saw

Kenneth using gestures that suggest drawing in crescent-shaped motions at the conclusion of his suggestion (line 3). Kenneth's and Earl's comments illustrate that the boys were still not satisfied with Tim's notational use for representing sound/sound waves, and wanted him to incorporate the crescent-shaped notations into his drawings. The other boys continued to critique Tim's notational use throughout the four-day exploration because all of his drawings used a "wavy-like" notation (see Figure 34). The boys' critiques were cloaked within jokes, or acts of *Signifying* as highlighted in Chapter 4, but Tim maintained his use of this non-crescent notation. For example, Figure 36 illustrates a drawing from Tim during Session Four that depicted sound as lasting for one minute (see A), 5 minutes (see B), and 30 minutes (see C).

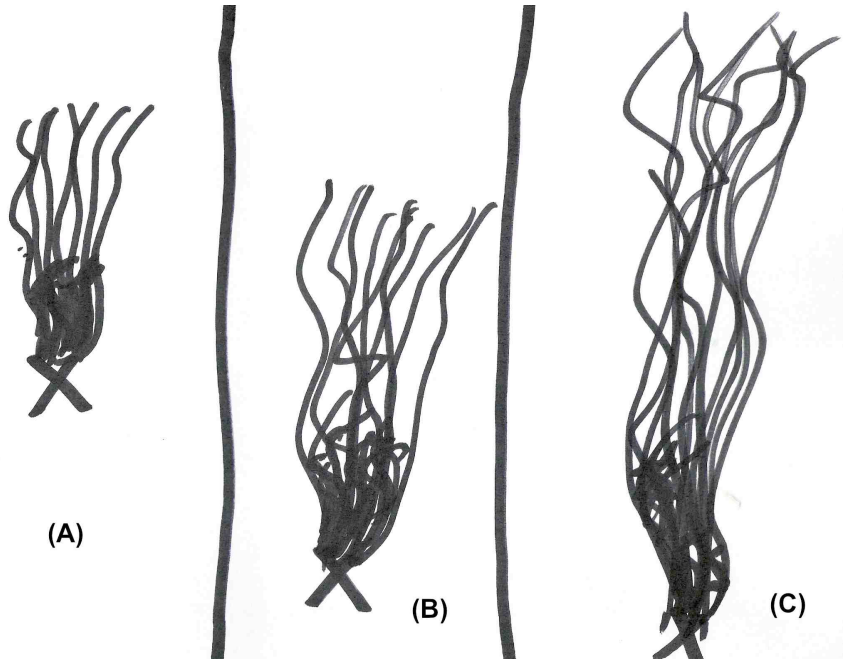

Figure 36. Tim's drawing depicting sound lasting for various durations – 1 minute (A), 5 minutes (B), and 30 minutes (C).

When it was time to analyze Tim's drawing, I asked the group, "So, how is Tim showing that this one (see C, Figure 36) last longer than that one (see A, Figure 36). The boys responsed (see Excerpt 6.3):

Excerpt 6.3. Critiquing Tim's drawing from Session Four

1. Earl: I notice how he did it; how he made like those lines short [A], and those lines the longest [C] which means those [C] lasted thirty minutes.
2. Chris: Okay.
3. Isaac: He made his grunge [the group burst into laughter], I meant his waves…
4. Chris: You said grunge? Oh, okay //

5. Floyd: That's how the hair look on a grunge

Here, the boys were able to decipher what Tim's intentions were as he represented the various times in which the sound lasted. Earl (line 1) explicitly interpreted Tim's use of varying length as the method for communicating the variation. Although it was evident what Tim was attempting to illustrate, Isaac (line 3) included a bit of sarcasm about Tim's choice of notation as he described the notation as a "grunge." Although I have never seen a "grunge," the boys told me that it is a character in a recent movie that had hair and resembled Tim's notation. Isaac's (line 3) utterance was intentionally fashioned to tease Tim about his notation, as evident by the group laughter that immediately followed, and his omission of any other information regarding the drawing. Jokes regarding the appearance of Tim's notations continued throughout the four days. As with other acts of *Signifying* previously described, the boys shared an implicit understanding that Tim should not take the teasing to heart. By my account, Tim did not allow the teasing to alter his approach for he continued to use the "wavy-like" notation for all four days and he even, sarcastically, referred to his drawing as the "grunge" on several occasions. The next section will detail how the remaining four boys, Earl, Floyd, Isaac, and Kenneth used various representational elements to specifically represent the idea of change in volume over distance.

Modifying the Crescents to Represent the Change in Volume over Distance

The analysis reveals that the boys used each of the aforementioned representational elements, *a) line weight / line type, b) compactness of sound waves,* and *c) change in length of the crescents (i.e., increasing or decreasing length),* at various instances throughout the four-day exploration. Despite the group's common use of these elements, I found that, at times, the boys had different meanings for individual elements. For instance, the boys constructed fairly stable meanings for the elements line weight / line type and compactness. Typically, when the boys incorporated a thinning or lightning of the crescent's line weight, the group interpreted the element as representing a decrease in volume. Similarly, when the boys incorporated crescents as becoming less compact, or farther apart, the group interpreted the element as representing a decrease in volume. In contrast, some of the boys associated an increase in length of the crescents with a decrease in volume, while others associated an increase in length of the crescents with an increase in volume. Interestingly, the meaning of an increase in length of the crescents to depict volume was not stable for a given boy; sometimes it meant a decrease in volume while other times it meant an increase in volume, based on the context or nature of the task.

During Session One, as discussed in the preceding chapter, the boys collaboratively constructed the crescent-shaped notation (see Figure 35) as the agreed upon notation to represent sound transmission. Although three of the group members', Kenneth, Isaac, and Tim, original drawings did not utilize this notation, two of these boys (Kenneth and Isaac) subsequently used the crescent-

shaped notation for their remaining 10 drawings. Thus, four of the five boys (Earl, Floyd, Isaac, and Kenneth) utilized the crescent-shaped notation to represent sound transmission in a total of 10 – 11 drawings, out of 11 total drawings per youth. After determining that four of the five boys agreed upon the use of the crescent-shaped notation, I elected to follow Sherin's (2000) focus on the boys' modification of line segments and use of temporal sequencing in order to further highlight and examine the meanings that the boys associated with various representational elements. In the rest of this chapter, I briefly analyze the representational elements used by each of the boys: Floyd, Isaac, Earl, and Kenneth. I begin the analysis by exploring two of Floyd's drawings during the four-day exploration.

Floyd's Use of the Representational Elements. I begin this analysis with an examination of two of Floyd's drawings and how he utilized the three aforementioned representational elements in order to represent change in volume over distance. Throughout the four-day exploration, the basic meaning that Floyd associated with the crescent-shaped notation remained stable. Excerpt 6.4 illustrates Floyd's basic understanding of the representational element of a change in the length of the crescent notations, as depicted in Figure 35[16]:

[16] When referencing the "basic" crescent-shaped notion, I am referring to an ideal depiction of this representation. For example, the basic version would include crescents, but the spacing between each crescent and the line weight / line type would be consistent throughout. Additionally, the crescents' increasing length would also remain consistent throughout. So, rather than representing an ideal, Figure 35 is just an example of how the crescents were typically utilized by the boys.

Excerpt 6.4. Floyd's understanding of the change in crescent length

> Because, mine's, the bigger the lines, the more space sound has to spread out. When that happens, they spread out. It's not as concentrated, as like right around you [sound producer]. So, I'll say the bigger the lines, the less the sound is.

Here, Floyd articulated his understanding that an increase in the length of a crescent notation indicates a decrease in the sound's volume.

Although Floyd's understanding of the basic crescent-shape remained fairly stable throughout the four-day exploration, he incorporated multiple modifications to this basic notation in order to create varied meanings across different contexts or tasks. For example, during Session One, the boys were presented with the task of representing sound transmission from a tambourine that was played from a room on the other side of an adjacent, solid wall. Figure 37 shows Floyd's modification of the basic crescent notation (see Figure 35) in relation to this new experience with sound transmission.

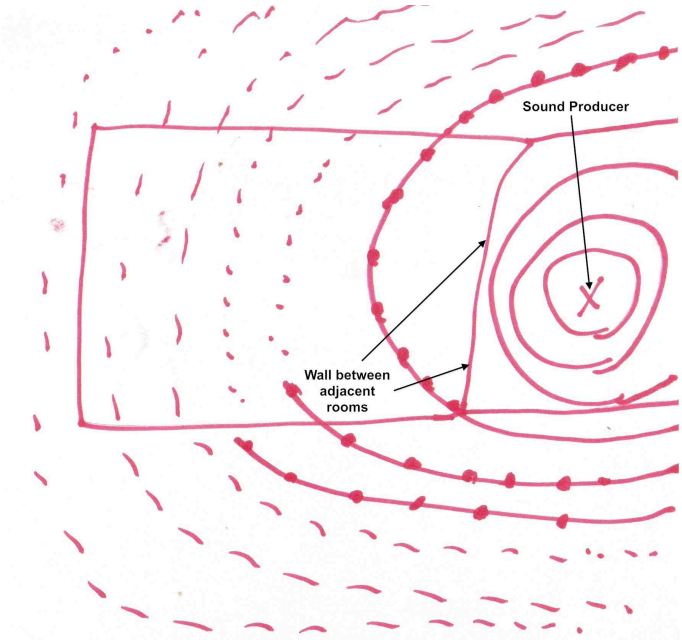

Figure 37. Floyd's modification of the crescent-shaped notation in relation to sound traveling through a solid wall.

To indicate change in volume over distance, Floyd incorporated polka dots into his representation, which eventually became dashed lines. After presenting his drawing to the group, Floyd (see Excerpt 6.5) explained the meaning he associated with his use of the polka dots:

> *Excerpt 6.5. The meaning of the polka dots for Floyd*
>
> Yeah. Like, when you [sound producer] was in that room, you had the tambourine. My drawing, I made the lines solid. It was surrounding you in that room because there was nothing breaking up the noise. But, when they [sound waves] started to expand outside of that room, there was a whole bunch of materials that was in the way of that. So, it kind of broke up the sound and

muffled the sound a little bit. So, that's why it's in polka dot or dot form.

Here we see that Floyd's use of change in the length of the crescents remained stable: he is using the notation to indicate the volume decreases as length of the crescents increase. Despite this stability in meaning, Floyd acknowledged his notation no longer only highlights the relationship between volume and distance, but also includes a relationship between volume and the medium through which sound travels, in this case a solid wall. For this reason, he explained that he modified his crescent notations into a "polka dot form" because "there was a bunch of materials that was in the way" that muffled the sound. Floyd's use of the "polka dot form" highlighted and represented an additional cause for the decrease in volume: the distance the sound traveled, as well as traveling through the solid wall. To accomplish this, Floyd incorporated two of the representational elements: modifying line type and a change in the length of the crescent shaped notation.

In addition, I believe that Floyd's use of the "polka dot" notation was intended to describe a "process" of decreasing volume. The first three crescent waves surrounding the sound producer are actually solid circles (see Figure 37). The meaning that Floyd associated with these three waves is compatible with his original understanding of increasing length of crescent waves (see Excerpt 6.4): as the wave length increases, the volume decreases. The fourth crescent wave is also solid, but includes polka dots, indicating that a modification is taking place. I believe that Floyd included the polka dots to represent the point at which he

thinks the sound begins to be "broken up" (see Excerpt 6.2) by the solid wall. According to his drawing, the breaking up process continues through the fifth and sixth crescent waves. For both of these waves, Floyd has modified half of the crescent as a solid line with "polka dots" and the other half simply with "polka dots."

Furthermore, drawing on Sherin (2000), I interpret Floyd as representing a temporal sequence of the sound breaking up, through these first six crescent-shaped notations. Finally, the three remaining crescents waves are represented utilizing only the "polka dot" notation, thus further highlighting the decrease in volume. So, in this drawing (see Figure 37), while Floyd is using a stable consistent meaning the increasing wave length to indicate he also recognized the need to manipulate this notation in order to provide additional information to more accurately represent his experience. He intended to represent the decrease in volume of sound that resulted from traveling through a medium: the solid wall separating the sound producer and the listeners.

In Session Four, the boys were again presented with the task of representing sound transmission through a solid barrier, but here the barrier was a curtain rather than a wall. In response to this task, Floyd created the drawing documented in Figure 38. When I asked the group, "what happens to the noise or the sound," Floyd answered, *"It's [the volume] not as strong."*

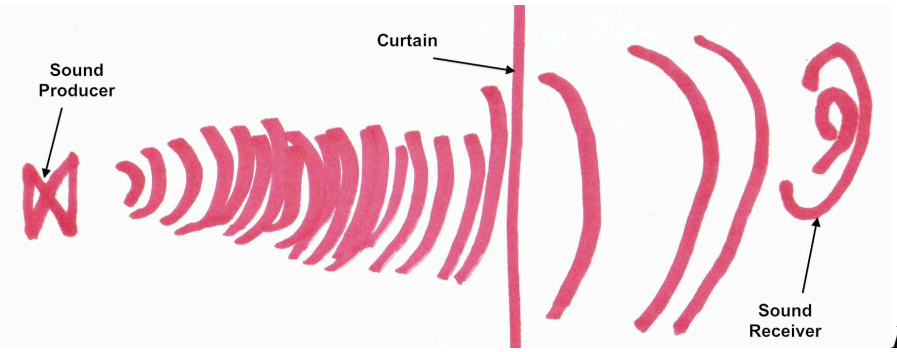

Figure 38. Floyd's representation of sound transmission through a curtain.

Here, Floyd continued to use some of the same representational elements he had used previously. He represented a decrease in the sound's volume with an increase in the length of the crescents, indicating that the volume decreased after going through the curtain. Based on this analysis, I hypothesize that the meaning that Floyd associated with the basic crescent shaped notations remained stable, but that he modified his use of the notations to incorporate and highlight context-specific elements from one task to another (e.g., the shift in listening to a sound through a solid wall vs. a curtain as depicted in Figure 37 to Figure 38). Floyd also incorporated the representational element of *compactness* consistently in his drawings. Prior to traveling through the curtain (see Figure 38), the crescents are more compact, or closer together. After going through the curtain, the crescents are less compact, or are farther apart. Analyzing this drawing in relation to Floyd's response of the sound being "not as strong" after passing through the curtain, I interpret the representation to be showing that the less compact the crescents, the quieter the volume.

In Figure 38, Floyd combined two representational elements, line type (i.e., polka dots and lines) and change in length of the crescent notation, to communicate the change in volume over distance. The polka dots, or dashed lines, were used to distinguish the relationship between volume and distance (i.e., the solid crescents surrounding the source of sound) versus the relationship between volume and medium (i.e., the polka dot formed crescents). In Figure 43, Floyd again combined two representational elements, but this time included change in length of the crescent notations and compactness. I believe that Floyd was experimenting with alternative representational elements within his drawings in order to develop a refined representation of the change in volume over distance and how volume is affected by both distance and by a medium. I argue that Floyd demonstrated his representational competencies (diSessa & Sherin, 2000; Azevedo, 2000) through his ability to utilize and combine several features within a drawing.

Isaac's Use of the Representational Elements. I continue this analysis of the boys' use of representational elements with an examination of two of Isaac's drawings and how he incorporated the three representational elements. During Session Four, I presented the boys with the following task, "on the right side [of the paper], I want you to draw how the sound waves would look if it's a loud sound, alright? On the left side [of the paper], I want you to draw sound waves how they would look if it's a quiet sound." In response, Isaac produced the

drawings displayed in Figure 39. The drawing on the left, A, represents quiet volume; the drawing on the right, B, represents a loud volume.

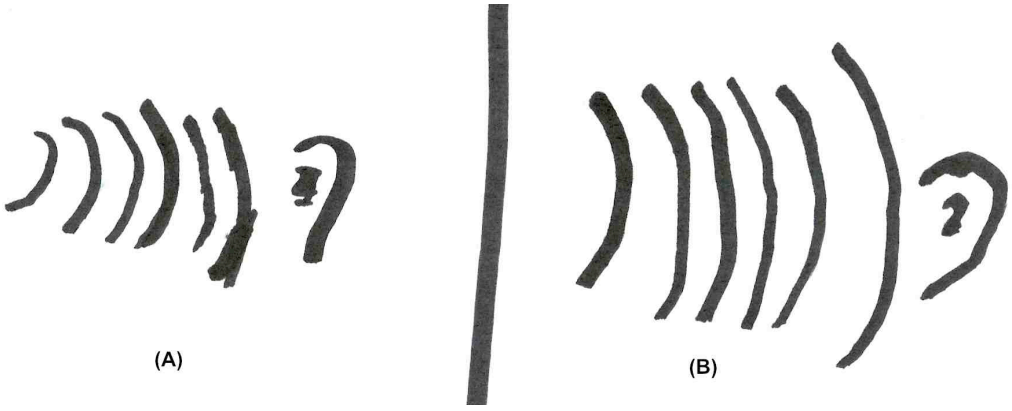

Figure 39. Isaac's drawing of different volume levels (left: quiet; and right: loud).

Following the presentation of this drawing to the group, Isaac provided the following explanation (see Excerpt 6.6) to his fellow group members:

> *Excerpt 6.6. Isaac's explanation of his drawing*
>
> Alright, the wave [referring to Figure 39, B – loud condition] is actually darker than here [referring to Figure 39, A – quiet condition] and when it [Figure 39, B - loud] hits your ear, it's bigger. It's a bigger wave then when it hits your -- than this one [Figure 39, A - quiet], 'cause when this [Figure 39, A - quiet] hits your ear, it's a smaller wave and it stays close together and not as dark.

Here, Isaac introduced the meanings he associated with each of the three representational elements. First, through his saying, *"when it [Figure 39, B - loud] hits your ear, it's bigger. It's a bigger wave when it hits your ear,"* Isaac

introduced the meaning of an increase in the length of the crescent wave as indicating an increase in the sound's volume. This is the opposite of the meaning that we saw Floyd assign in his drawings and clearly illustrates a tension within the group of boys regarding the meanings associated with various representational elements. This contradiction, evident in Sessions One and Two, was not resolved by the end of Session Four.

In addition to associating oppositional meanings to the representational element of increasing crescent lengths, Isaac introduced line weight (i.e., "darker") and compactness (i.e., "close together") of the crescents as elements that differentiated between quiet and loud volumes. For Isaac, an increase in the crescent's length, darker crescents, and more spacing between crescents represented a loud sound, or increase in volume. Somewhat surprisingly, Isaac's understanding of the meanings of these elements (an increase in spacing represents an increased volume) is in direct contrast to Floyd's meanings associated with the same feature (see Figure 38).

Like Floyd did earlier, Isaac was also asked to draw a representation for another task in Session Four, representing volume traveling through a curtain. Prior to his production of the drawing, Isaac (see Excerpt 6.7) provided the following hypothesis for the outcome of the sound after traveling through the curtain:

Excerpt 6.7. Isaac's hypothesis of sound traveling through a curtain

I think it passes through the curtain and gets weaker.

Using Isaac's hypothesis as a basis for understanding his subsequent drawing (see Figure 40), I interpreted the drawing as depicting sound's volume getting "weaker" or decreasing in volume after passing through the curtain.

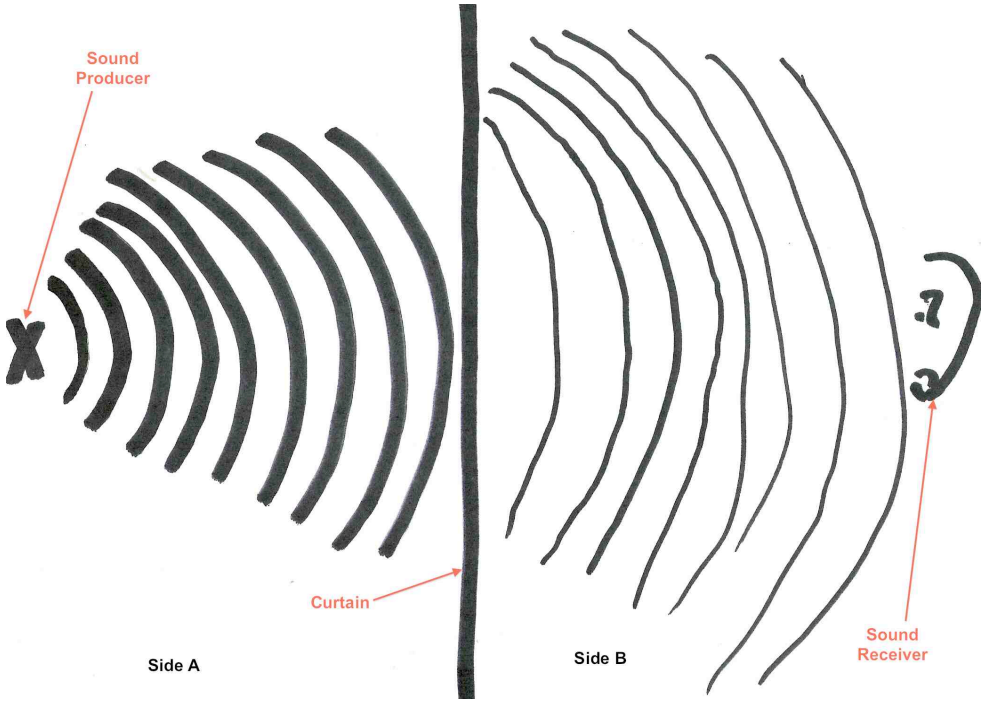

Figure 40. Isaac's drawing of sound transmission through a curtain.

In Figure 40, Side A of the figure depicts the sound's volume prior to traveling through the curtain, while Side B depicts the sound's volume after traveling through the curtain. Analyzing the drawing for the representational feature of change in the length of the crescents, in relation to his statement in Excerpt 6.7, I interpret that Isaac associated a different and opposite meaning to the increasing length of the crescents in this drawing, as opposed to his last drawing (see Figure 39). Initially (see Figure 39 and Excerpt 6.6), Isaac associated the increasing crescent lengths with an increase in volume and modified his use of this element to represent a decrease in volume (see Figure 40 and Excerpt 6.7).

In addition to the representational element of change in length of crescents, Isaac also incorporated the feature of line weight. In this case, the meanings that Isaac associated with line weight remained consistent across the two drawings (see Figure 39 and Figure 40). In Figure 40, as the sound is "getting weaker," the line weight of the crescents is getting thinner or lighter. It is interesting to note that in both of these figures, Isaac demonstrated a representational competency that enabled him to be able to coordinate at least two representational elements (line weight and line length) simultaneously.

Isaac's use of contrasting meanings associated with increasing length of crescents introduces a question: what is their origin? Is the task that prompted Figure 39 so different from the task that prompted Figure 40 that they would promote such variation? Or does the variation exemplify that children's conceptions of sound and how to represent sound transmission are flexible and in flux? It is important to note that despite the fact that Floyd and Isaac both utilized the same representational element (i.e., increasing length of crescents) they associated varying and opposing meanings to this particular element. These heterogeneous uses and meanings associated with the crescents will be explored further through the analysis of Earl and Kenneth's drawings.

Earl's Use of the Representational Elements. In response to the task in Session Four where the boys were asked to represent a loud and a quiet volume, Earl produced the following drawing (see Figure 41).

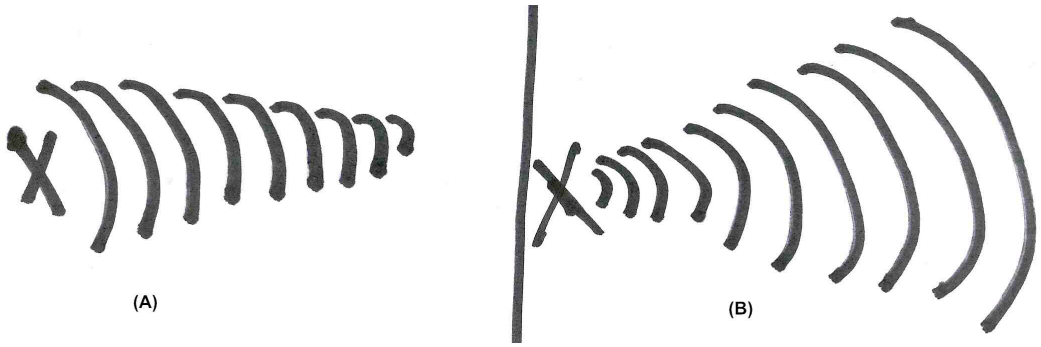

Figure 41. Earl's representation of a quiet volume (A) and a loud volume (B).

According to Earl, Drawing A represented a sound that was getting quieter, while Drawing B represented a sound that was getting louder. Earl provided the following description of his drawings (see Excerpt 6.8):

Excerpt 6.8. Earl's description of his varying volumes drawing

1. Earl: It's like -- I think that like the smaller it [the crescent] is, the smaller the sound is. But as it gets bigger, that's how the sound gets louder.
2. Chris: So, because it gets louder-- So, because it's getting bigger //
3. Earl: It starts out small and then the sound gets loud [pointing to Figure 41, B].
4. Chris: And this one is showing a quiet sound [pointing to Figure 41, A].
5. Earl: It starts out loud and then it gets quiet.

Excerpt 6.8 highlights the meaning that earl associated with longer and shorter crescents. In Figure 41, A Earl used decreasing length of crescents to illustrate a decreasing volume, while Figure 41, B he used increasing crescent lengths to

illustrate an increase in volume. I highlight this drawing because it was the only time that any member of the group used crescents that decreased gradually in length (see Figure 41, A).

Kenneth's Use of the Representational Elements. I continue the analysis with an examination of three of Kenneth's drawings. In the first two drawings, I draw from Kenneth's statements regarding his drawings, while the third drawing draws from a group interpretation of Kenneth's drawing. The first drawing I examine is from Session Two.

Session Two began with a brief discussion of what is a sound wave. After this discussion, the boys were asked to draw what you "mean by sound waves." In response, Kenneth produced the drawing in Figure 42.

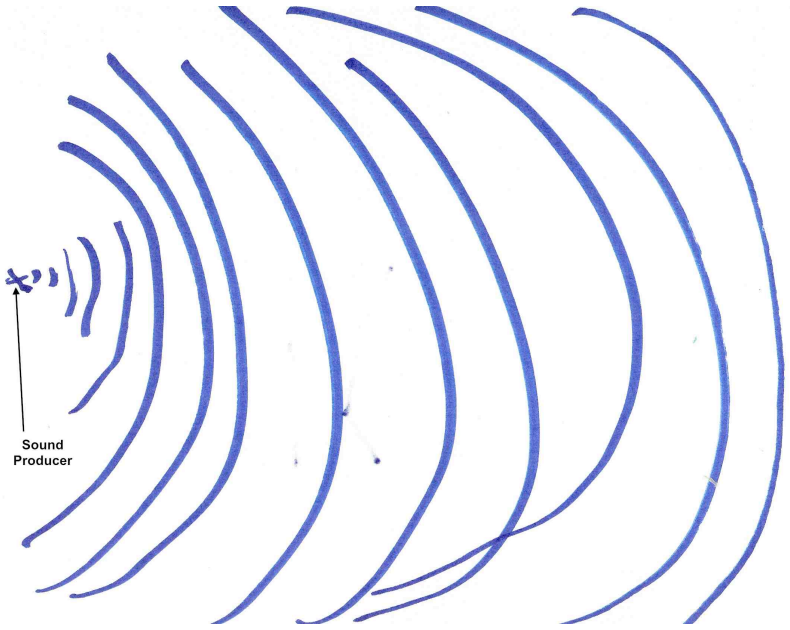

Figure 42. Kenneth's representation of sound waves.

When asked to describe his drawing, Kenneth said:

Excerpt 6.9. The meaning of larger crescents for Kenneth

1. Kenneth: The smaller the wave is, the louder it would be. And, as the waves travel out, it gets -- you don't hear it as much as you are up close.

2. Chris: So, the smaller the waves, you said, the louder it sounds? Why is that?

3. Kenneth: Because that means you're closer to what's making the noise.

Here, Kenneth tells us that similarly to the meaning Floyd (see Excerpt 6.4) assigned crescent waves, Kenneth intended an increase in crescent length to illustrate a decrease in the sound's volume (lines 1 and 3).

I now turn to analyze the drawing Kenneth produced in response to the task, Session Four, of representing a quiet volume and a loud volume. He produced the drawing shown in Figure 43.

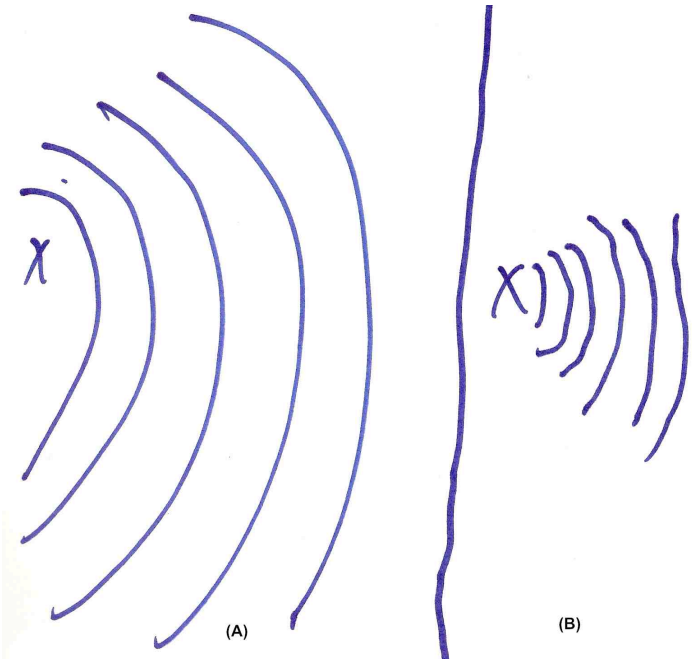

Figure 43. Kenneth's representation of a quiet volume (A) and loud volume (B).

Here, Kenneth incorporated two representational elements: a change in the length of the crescent and compactness. During a group analysis of the boys' drawings, Kenneth (Excerpt 6.10) provided the following description of his drawing.

Excerpt 6.10. Kenneth's represention of a quiet and loud volume

1. Chris: What does everybody notice about people's loud sounds?

2. Kenneth: [Pointing and referring to his drawing] The waves [in Figure 47, B] are more compact together and smaller [than waves in Figure 47, A].

3. Chris: What you mean more compact together? How so?

4. Kenneth: They're more closer together and travels far, but it -- I can't describe it.

5. Chris: You can't describe it?

6. Kenneth: It's loud, it's small, it's not lengthy, it's not long at all.

In Figure 43, one of the representational elements that Kenneth utilized is slightly different than *change in length of the crescent.* The crescents in both Figure 43, A and Figure 43, B are *increasing* in length, so that is not the element that he used here. Instead, the beginning and ending crescents in Figure 48, B are actually shorter in length than the crescents in Figure 48, A, thus *length* (line 2), and not the *change* in length within A or B, is being used to differentiate volume. In addition to the representational element of length of crescents, Kenneth also utilized the element of compactness (lines 2 and 4). By this, he intended to convey that the closer, or more compact the crescents were, the louder the volume.

Kenneth specifically tailored his use of the various representational elements to illustrate a loud sound as compared to a quiet sound. By experimenting with the spacing between the crescents and the actual length of the crescents, he expressed the ways in which he represented a loud sound. Kenneth and Floyd share the meanings associated with the spacing between the crescents: the closer the crescents, the louder the volume. In relation to the element of a change in length of the crescent, Kenneth (see Figure 42) used increasing crescent lengths to represent a decreasing volume.

During Session Three, the boys were presented with the task of representing how they would hear the sound from a television in an adjacent room versus the sound from a car's horn outside of the house. In response to this task, Kenneth produced Figure 44. In the excerpt (see Excerpt 6.11) immediately

following the production of the drawing, the group interpreted the meanings that they associated with Kenneth's drawing. I highlight this drawing and its corresponding discussion because several of the boys offer a differing interpretation of the representational features than what they described during the analysis of their own drawing. In addition, a new idea was introduced, "constant crescents."

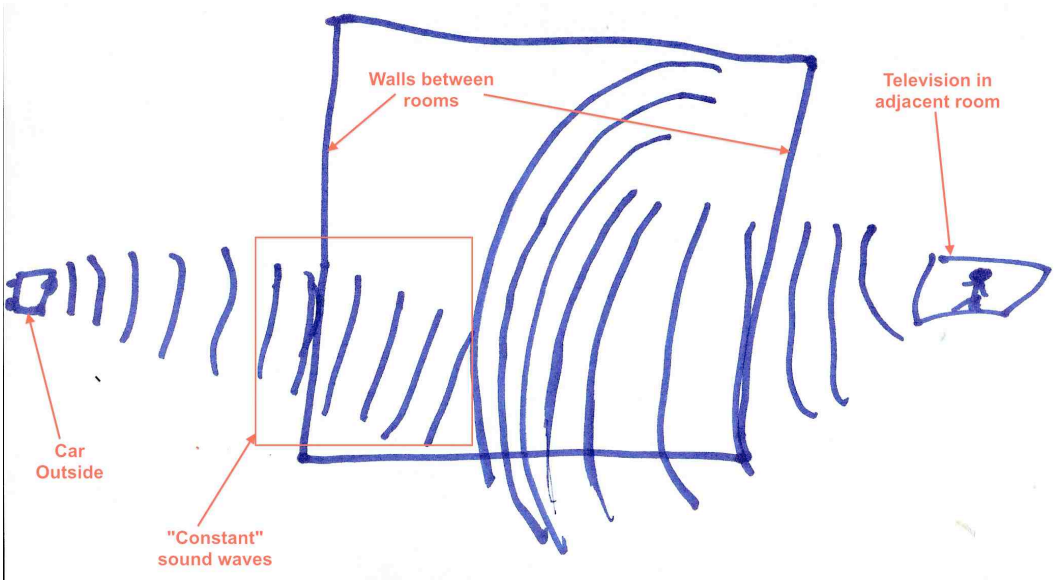

Figure 44. Kenneth's drawing contrasting sound from a car's horn and television.

Excerpt 6.11. Interpreting volume from Kenneth's drawing

1. Chris: So, how is Kenneth here showing that the horn is the loudest?

2. Kenneth: Because, even though this is not, it wasn't the longest one, the waves stay short so it kept it loud, and the volume of the horn didn't change -- so it stayed //

3. Chris: So, the short waves mean a loud sound //

4. Tim: That's what mine meant.

5. Kenneth: Yeah, a louder sound. And, um //

The group conversation continued as I posed the following question:

6. Chris: What things does anybody notice about Kevin's drawing here? Yeah, Earl.
7. Earl: His TV was, is like -- I thought that the car waves could have been bigger, and they [crescents from television] could have been a lil' bit smaller//
8. Kenneth: They are smaller.
9. Chris: Which ones?
10. Earl: The car waves, they cold have been bigger and they [crescents from the television] could be a bit smaller but that's probably how he was hearing it.
11. Isaac: I notice that his waves from the car stayed like, a little bit constant.
12. Chris: They stayed what? Oh, constant you said? Okay //
13. Isaac: From that point, they stayed constant //
14. Chris: Yeah.
15. Floyd: I noticed that the TV, the waves took up most of the room, than the horn //
16. Chris: Oh, okay-- what does that mean?
17. Floyd: It means that the, I guess it means that the TV was louder in this room [the room that the boys occupied during the

study] than the-- you could hear the TV more in this room [the room that the boys occupied] than the car.

18. Chris: And what does the waves staying constant mean to you?
19. Isaac: Well, I thought it mean that the-- that the sound stayed, like if you were closer to it, the car, then it'd be the same as if you were in here [the room that the boys occupied].

I feature this drawing and the conversation that followed it to highlight the tension that I recognized regarding the meanings that were associated with some of the representational elements. First, I call attention to Kenneth's (line 2) description of his drawing. Here, Kenneth explicitly stated that "the waves stay short, so it kept it loud." The meaning that Kenneth associated with the shorter crescents was a loud volume. In contrast, Earl (line 7) appeared to be suggesting the opposite. Again, the group has already agreed that the car horn would have the louder volume than the television playing in the adjacent room. Here, I believe Earl associated the meaning of longer crescent lengths with a louder sound, as he offered the suggestion, "the car waves could have been bigger." I also interpret Earl's (line 10) suggestion that because Kenneth was hearing, or experienced, the television's volume as louder that that would explain why the television waves were longer. Again, Earl's statement is interesting to note when we think about Enyedy's (2005) definition of representation as "communicating our experiences." Earl was able to implicitly accept Kenneth's drawing because it was "probably how he was hearing it" (line 10).

As the conversation continued, Floyd (line 17) also interpreted Kenneth's drawing as depicting that the television produced a louder volume. Again, as I noted earlier (see Figure 37 and Figure 38), Floyd consistently associated longer crescents with a quieter volume, so it was interesting to notice his interpretation of Kenneth's drawing. The interaction between Kenneth, Earl, and Floyd brings attention to the friction underlying the construction of a shared meaning for representations.

Lastly, Kenneth's drawing also offered the opportunity for the group to further explore the meanings they associated with the element of *change in length of the notation.* The boys had previously investigated this element by associating meanings to crescents that are either increasing or decreasing in length. Kenneth's drawing offered a new idea; what would be the meaning associated with crescents that stay "constant" (see Figure 44). Isaac (lines 11 and 19) elaborated on this idea, interpreting Kenneth's illustration as communicating that the volume of the car remained constant during that period. Although the meaning of the "constant" crescents was not taken up further, it still provided an opportunity to explore other meanings of the representation.

Summary

This analysis of the B-Street boys' use of various representational elements and the meanings associated with them offered a perspective on the various competencies that the group demonstrated regarding the production and interpretation of scientific representations. In addition, this analysis recognized

some of the difficulties and complexities that children face as they engage in these practices. While recognizing some of the difficulties that children face, Sherin (2000) stated that in order for representations to be successful and to have the possibility of developing into conventional use, children must maintain a consistent meaning for the usage of the incorporated representational elements. In the current study, the boys exhibited heterogeneous uses for three representational elements throughout the four-day exploration of sound transmission, including: *a) change in length of crescent-shaped notation, b) compactness of crescent-shaped notations, and c) line weight, or line type, applied to crescent-shaped notations.* Thus, I offer a view of representational competence that could be characterized by the boys' awareness and abilities in designing multiple uses for these elements, but remaining in continual development as they regularly experiment with alternate uses of the same elements. In addition, I argue, through this analysis, that the development of these individual boys' competencies were informed and aided by their participation in the production and interpretation of these elements within a group setting, thus making a case for future work that explores the relationship between culture and cognition in the development of scientific representations (Nasir, 2000, 2002; Saxe, 1999, 2005).

The boys' use of increasing or decreasing length of crescents carried multiple and dynamic meanings within the group, as they represented the sound transmission idea of *change in volume over distance.* This variation in meaning highlights the difficulty that persisted within the group in developing a shared understanding of several representational elements. Even though four of the five

boys utilized the crescent-shaped notation, by the end of the fourth session there still was no consensus regarding the meanings associated with the notations. The analysis here highlights how representations are dependent upon the perceptions of those that are interpreting their functions and the contexts within which the representation and the associated elements are being interpreted. There were several instances in which a representational element in one context was associated with the increase in volume and in another context associated with the decrease in volume. All of this is important as we begin to think about the role of negotiation in the general development of a representation. One concern of this analysis is the length of time during which the boys engaged in and were observed. Specifically, if the boys participated in a longer investigation, would they have negotiated more stable meanings associated with several elements? Would they have come to the conclusion that the crescent-shaped notation did not meet all of their needs and created a new notation or would they have simply negotiated a modified meaning for the crescent-shaped notation?

CHAPTER 7:

DISCUSSION, CONCLUSIONS, AND IMPLICATIONS

The purpose of this study was to investigate the intellectual and linguistic resources that a group of 7th and 8th grade African American boys exhibited while exploring the science of sound and the practice of representation. In this final chapter, I will organize and expound upon the findings from this dissertation research and consider what the findings imply for future research with children from communities of color. The following discussion is divided into four primary sections – discussion of key findings, implications of the findings, limitations of the study, and future research directions.

Discussion of Key Findings

The study in this dissertation was guided by three research questions that inquired into the process by which a group of 7th and 8th grade African American boys developed a similar set of beliefs and competence with regards to representing the scientific phenomenon of sound transmission:

1. What intellectual and linguistic resource(s) did the boys display while producing, interpreting, and critiquing invented representations of sound transmission?
2. What ideas, or aspects, of sound transmission do a group of urban, 7th and 8th grade African American boys collectively explore while producing, interpreting, and critiquing invented representations of sound transmission?

3. What is the range of representational features that a group of urban, 7th and 8th grade African American boys utilize while producing and critiquing invented representations of ideas, or aspects, of sound transmission?

The analyses utilized in this dissertation yielded very interesting insights into children's engagement with the practice of representation and critiques of these practices. In addition, understandings of children's conceptions of sound transmission were also made evident during the analyses. In the next section, I discuss the findings presented in Chapter Four, Five, and Six, highlighting how the five boys developed a competency in producing, interpreting, and critiquing representations of sound transmission.

The first research question sought to answer *what intellectual and linguistic resource(s) did the boys display while producing, interpreting, and critiquing invented representations of sound transmission?* In exploring this question, I identified the boys' use of *Signifying* (Mitchell-Kernan, 1977; Smitherman, 1977; Spears, 2007), a linguistic resource with deep roots within the African American community, during their participation in the critique of drawings representing sound transmission. Specifically, I found that the boys used of indirection, sarcasm, and braggadocio.

1. *Components of indirection and sarcasm were instrumental in the group's collective exploration of each other's drawings and assertions. Signifying,* specifically indirection and sarcasm, was used to problematize the

meanings of drawings and ideas, and to further investigate the group's understanding of sound transmission. As individual boys presented their drawings for critique, other group members utilized elements of indirection and sarcasm to question the validity of an assertion regarding sound transmission or the effectiveness of a drawing in representing a particular aspect of sound transmission. Indirection and sarcasm were primarily exhibited through instances of group laughter when a drawing or an idea was presented, by challenging the validity of drawings or ideas through the posing of questions that possessed multiple possible interpretations, and the teasing of an individual drawing by "cracking jokes" or other humorous expressions. Although these practices have been studied most often in discourse practices outside of the science classroom (Gates, 2010), the boys used their adeptness with these skills to create a productive and positive space in which they could participate in the practice of critiquing scientific representations.

2. *Components of braggadocio were utilized by the boys to support the reasoning behind their assertions or decisions for representing sound transmission in their drawings.* Braggadocio, another example of *Signifying,* was utilized during instances in which the boys' drawings or assertions were challenged, typically through elements of indirection and sarcasm described above. For example, Floyd's (see Chapter 4) statement, *"I'm about to get all scientific on you,"* was met with light laughter within the group. Despite the group's explicit recognition of humor, Floyd's

statement also functioned to position the response within a "scientific" framework and established credibility for his drawing.

Thus, I found that the boys' use of *Signifying* was key to their engagement in the practice of critique.

The second research question sought to answer, *what ideas, or aspects, of sound transmission did the boys collectively explore during the four-day exploration?* During the four-day exploration of sound transmission, the boys explored several ideas regarding sound transmission, including: *directionality* of sound transmission, *distance* in which sound travels, change in *pitch*, *change in volume over distance, reflectivity* of sound waves, and *duration* for which a given sound lasts. Despite each of these ideas appearing at some point during the exploration, some ideas were explored in depth than others. For example, *reflectivity* was explicitly explored during the boys' production of their first two drawings during Session One. After drawing two of Session One, *reflectivity* did not come up again during the boys' discussions. In contrast, the idea of *change in volume over distance* was first introduced during the critique of the boys' first drawing in Session One and remained a topic of exploration during the four-day exploration. Additionally, the idea of *directionality* was explicitly explored through discourse and drawings during the entire Session One, but only briefly mentioned again during the analysis of Isaac's first drawing. In relating these findings to the literature regarding children's conceptions of sound, I would like to highlight two specific findings:

3. *Children's ideas regarding sound transmission are not fixed, stable misconceptions that can be "fixed" through instruction.* Literature within the misconceptions framework has described children's intuitive knowledge as "well-established" (Slotta & Chi, 2006, p. 252), and literature regarding children's conceptions of sound transmission has often been situated within this ideology (Barman et al., 1991; Lautrey & Mazens, 2004; Mazens & Lautrey, 2003). For example, Barman et al. (1991) found that 5th graders believed that sound reached them by bouncing off of things, such as the walls or the ceiling. In this dissertation study, I too found that several of the boys thought that the tambourine's sound reached them because it bounced off of the wall (Chapter 5, see Excerpt 5.1 and Excerpt 5.2). I recognized that this conceptualization of "bouncing off of the walls" occurred when the boys experienced sound from within the same room as the source of the sound. In line with my belief that children's ideas regarding sound transmission derive from a "web of ideas" (Gustafson, 1991) and are not fixed or "well-established" (Slotta & Chi, 2006), the boys highlighted the ability of sound to travel through walls when the group experienced sound from an adjacent room and through a solid wall. So, I believe that the context of the task (i.e., experiencing sound *within* the same room or experiencing sound *between* rooms) played an integral role in the aspects of sound transmission that the boys deemed important to highlight in various drawings.

4. *The drawings were instrumental in the ideas that the boys explored.* In addition to the context in which the boys experienced the tambourine's sound, I also believe that the drawing tasks in and of themselves were instrumental in contributing to the ideas the boys explored. For example, Kenneth's drawing (see Figure 28) and Floyd's drawing (see Figure 30) were conducive to the group's exploration of *reflectivity* because they depicted sound waves bouncing off of the walls. Likewise, the drawings of the other boys highlighted various aspects of sound transmission that became a topic for further exploration. For example, when Tim's drawing (see Figure 31) was presented to the group, the boys used it as an opportunity to further explore their understanding of the *distance* in which sound travels and its relationship to *change in volume.* In short, the actual drawings produced by the boys and their interpretations of these drawings were key to establishing the sound transmission ideas they examined.

The third research question that this dissertation sought to answer was, *what is the range of representational features that the boys utilized while producing drawings of sound transmission?* The representational features utilized by the boys during the four-day exploration regarded their use of the crescent-shaped notation and included: *compactness* of the crescents, *line weight and line types* of the crescents, and the *increasing or decreasing lengths* of the crescents. Here, I will to specifically describe the findings involving the boys' production and use of these elements. First, I describe a view of competency that involves the

boys' production and manipulation of these elements in order to highlight various aspects of sound transmission. Next, despite the boys' competency in utilizing various elements, I focus on the complexities involved in developing a shared group meaning for them.

5. *The boys exhibited a form of meta-representational competency (MRC) that included the production and modification and manipulation of the crescent-shaped notation.* The boys exhibited competencies in manipulating and modifying an existing notation, the crescent-shaped notation (Eshach & Schwartz, 2006), in order to create new meanings for the notation and to extend previous meanings associated with it. Throughout the four-day exploration, the boys developed methods for incorporating one element or a combination of elements into a drawing in order to highlight a specific aspect of sound transmission. For instance, the representational feature of line weight was typically utilized to highlight the aspect of change in volume over distance. Volume was represented as getting quieter as the line weight of the crescents "thinned out." As the boys progressed through the four-day exploration, their competencies became more evident as they attempted to produce more complex representations for change in volume over distance. Some drawings incorporated both the representational features of line weight and compactness within the same drawing. Volume was represented as decreasing as the crescents became thinner and as they grew farther apart. Thus, the boys exhibited a developing knowledge of the production and

use of scientific representations of sound transmission. Despite the competencies exhibited in developing these features, the meanings associated with these features highlighted another level of complexity that will be discussed in the next section.

6. *The development of meaning for representational features was filled with various complexities.* The negotiation process of constructing meaning of a drawing highlighted the complexities in developing a conventional understanding or meaning for representations. At the conclusion of the four-day exploration, the boys still had not negotiated a standard group understanding or meaning for the increasing or decreasing length of the crescent-shaped notation. For instance, Isaac typically maintained that as the length of the crescents increased, volume also increased. In contrast, Floyd typically maintained that as the length of the crescents increased, volume decreased. Thus, different boys were incorporating the same representational feature to highlight different aspects of sound transmission. Additionally, the meanings associated with the representational elements fluctuated over time for individual boys. For example, increasing length of crescents represented increasing volume in one context, while in another it represented decreasing volume. I believe that this finding is consistent with the previous research that argues that children's ideas regarding sound transmission are a web of related ideas and in flux rather than fixed or "well-established,."

Implications of the Findings

The findings described in this dissertation have the potential to lay a knowledge foundation that leads increasing access to high-quality opportunities in science learning for children from communities of color. The findings imply that both 1) the educational research community and 2) teachers could play important roles in redesigning instruction based on the foundation that this research establishes. This section presents the theoretical, methodological, and pedagogical contributions of this dissertation for working with children from communities of color.

Theoretical contributions. A goal of this research was to challenge the deficit-oriented perspectives that are often associated with children from communities of color, specifically in relation to science education. The findings from this study support my argument for re-positioning children from these communities as owners and developers of scientific knowledge. I maintain that in order to develop comprehensive theories of learning within science education, research needs to include children from varied communities and life experiences without positioning them as deficient. For example, instead of conceptualizing the boys as "at-risk" and their ways of thinking, talking, and participating as atypical from "the norm," this study used a lens of student resources for learning science. This lens enabled the boys' practice of *Signifying* to be seen as critical to the boys' development in science, as opposed to seeing it as a practice that is utilized during out-of-school moments or as non-productive to formal learning as it is

often viewed in school. By serving as a counterstory (Solórzano, 2002) to often utilized theoretical perspectives associated with children from communities of color, this study looks to promote the exploration and use of theoretical frameworks that examine the *resources* that these children bring to science. Future frameworks will, in turn, impact the methodological choices that researchers make, as I discuss below.

Methodological contributions. This research could potentially inform the design methods of future studies that investigate issues of teaching and learning within communities of color. Specifically, previous studies have often positioned the ways of knowing, talking, and participating of children of color as disconnected from those privileged in school science. This dissertation study, from the onset, positioned these children as sources of scientific knowledge, the study of whom, could potentially lead to understanding generative learning opportunities for *all* children. The methodological approach in this dissertation sought to identify the intellectual and linguistic resources exhibited by this specific group of children. Thus, I intentionally set out to avoid the comparison of these children's linguistic practices with their white, middle-class counterparts. Instead I wanted to document and describe the boys' practices as *resources* for developing scientific and representational understandings. By identifying and documenting *Signifying* as a linguistic resource in learning complex science and in developing meta-representational competencies, the findings from this study position it as a potentially valuable topic for future research in science.

In addition to the methodological design of this study, I want to highlight the approach I took to data analyses. I would suggest that educational researchers need to pay close attention to how we identify and determine "what it is that children know" regarding a specific domain. In this study, I incorporated various modes of representation (e.g., talk and drawing) and various ways of framing tasks in order to elicit a range of the boy's ideas regarding sound transmission and a range of ways for describing them. Both tasks and contexts impacted the aspects of sound transmission that the boys highlighted and explored as a group. If this study had relied on data provided only in the first drawing from Session One, where the boys experienced sound within the same room, my analysis might have concluded that the boys believed that sound does not travel though solid walls. However, by providing them a range of exploration opportunities, in different contexts, to communicate their understandings, this study serves as a model for capturing a wider range of children's understandings regarding sound transmission. Although this dissertation specifically highlights the experiences of African American boys, it carries important implications for working with all children.

Instructional contributions. The findings in this study provide a small window for viewing what children from communities of color are capable of when they are given opportunities to build upon the resources they develop within their communities. As described earlier, many urban classrooms with large numbers of children from communities of color are dominated by instructional

approaches that are primarily teacher-centered. Unfortunately, all too often a deficit-oriented perspective of the practices and abilities of these children inform these practices. When the boys in this study were provided opportunities to explore big ideas of sound transmission through talk and drawing, they were able to bring powerful and diverse skills to the table. Finally, these findings highlight the inherent potential power of social interaction in the development of an individual's learning. The boys developed their individual understandings of sound transmission and the practice of representation together, as they collectively explored these ideas. Through a process of critique and negotiation, they were forced to reflect on and analyze their previous beliefs and understandings, and further refine them.

Limitations of the Study

The key findings and implications discussed in this chapter need to be qualified by noting some of the limitations of the study.. These include the following:

1. The duration of the study was too short to provide a deeper analysis of the negotiation process in which representations become conventions within communities of people. With limited time and access to the boys, I made the decision to conduct a four-day study, instead of a longitudinal study over three to four months.
2. The small sample size limits the study's generalizability.

3. Although the informal nature of the research site (one of the boy's homes) allowed for flexibility, it was not a classroom setting. Therefore, findings with explicit connections for educators and educational institutions are generally limited.
4. The analysis highlighted one intellectual and linguistic resource manifested in the African American community (Signifying) and thus may give the impression that it is the only resource to be aware of while interacting with children from African American communities.

Final Thoughts

Additional research is necessary for exploring the intellectual and lingustic resources that children from communities of color bring to the science classroom. The objective of this research was not to highlight a single intellectal and linguistic resource that educators and educational researchers could expect to witness when working with African American boys. Instead, the objective was to highlight an approach to teaching and learning that investigated and highlighted the resources that children from communities of color have developed within their communities and from their varied life experiences that may be conducive to scientific exploration and language. Recognizing that all children bring a variety of resources that can be utilized and further developed in order to expand their understandings of scientific concepts or a representational practices must be continually explored if we are to begin the process of addressing inequitable access to science opportunities.

CHAPTER 8:

BIBLIOGRAPHY

Azevedo, F. (2000). Designing representations of terrain: A study in meta-representational competence. *Journal of Mathematical Behavior, 19,* 443-480.

Ballenger, C. (2004). The puzzling child: Challenging assumptions about participation and meaning in talking science. *Language Arts, 81*(4), 303-311.

Bang, M., & Medin, D. (2010). Cultural processes in science education: Supporting the navigation of multiple epistemologies. *Science Education, 94*(6), 1008-1026.

Banks, J. (1983). Multicultural education: Historical development, dimensions, and practice. *Review of Research in Education, 19,* 3-49.

Barman, C., Barman, N., & Miller, J. (1996). Two teaching methods and students' understanding of sound. *School Science and Mathematics, 96*(2), 63-67.

Barton, A.C. (2000). Science education in urban settings: Seeking new ways of praxis through critical ethnography. *Journal of Research in Science Teaching, 38*(8), 899-917.

Bowie, L. (2010, October 20). Fewer black males are dropping out of school in Baltimore. *The Baltimore Sun,* pp. A1, A12.

Brizuela, B. (1997). Inventions and conventions: A story about capital numbers. *For the Learning of Mathematics, 17*(1), 2–6.

Brown, B. (2006). "It isn't no slang that can be said about this stuff:" Language,

identity, and appropriating science discourse. *Journal of Research in Science Teaching, 43*(1), 96-126.

Brown, B., & Reveles, J. (2005). Scientific literacy and discursive identity: A theoretical framework for understanding science learning. *Science Education, 89*(5), 779-802.

Chandler, D. (2007). *Semiotics: The Basic.* New York, NY: Routledge.

Chi, M., Slotta, J., & De Leeuw, N. (1994). From things to processes: A theory of conceptual change for learning science concepts. *Learning and Instruction, 4*(1), 27-43.

Danish, J., & Enyedy, N. (2007). Negotiated representational mediators: How young children decide what to include in their science representations. *Science Education, 91*(1), 1-35.

Davis, J.E. (2003). Early schooling and academic achievement of African American males. *Urban Education, 38*(5), 515-537.

Denson, C., Avery, Z., & Schell, J. (2009). Critical inquiry into urban African American students' perceptions of engineering. *Journal of African American Studies, 14*(1), 61-74.

diSessa, A. (2004). Metarepresentation: Native competence and targets for instruction. *Cognition and Instruction, 22*(3), 293-331.

diSessa, A., Hammer, D., Sherin, B., & Kolpakowski, T. (1991). Inventing graphing: Meta-representational expertise in children. *Journal of Mathematical Behavior, 10,* 117-160.

diSessa, A., & Sherin, B. (2000). Meta-representation: An introduction. *Journal*

of Mathematical Behavior, 19, 385-398.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas.* London: Routledge.

Duckworth, E. (1987). *Tell me more: Listening to learners explain.* New York: Teachers College Press.

Duckworth, E. (1996). *The having of wonderful ideas & other essays on teaching and learning.* New York: Teachers College Press.

Elmesky, R., & Tobin, K. (2005). Expanding our understandings of urban science education by expanding the roles of students as researchers. *Journal of Research in Science Teaching, 42*(7), 807-828.

Emdin, C. (2010). *Urban science education for the hip-hop generation: Essential tools for the urban science educator and researcher.* Rotterdam: Sense Publishers.

Enyedy, N. (2005). Inventing mapping: Creating cultural forms to solve collective problems. *Cognition and Instruction, 22*(3), 293-331.

Erickson, F. (1987). Transformation and school success: The politics and culture of educational achievement. *Anthropology & Educational Quarterly, 18*(4), 335-356.

Eshach, H., & Schwartz, J. (2006). Sound stuff? Naive materialism in middle-school students' conceptions of sound. *International Journal of Science Education, 28*97), 733-764.

Ferguson, A. (2001). *Bad boys: Public schools in the making of Black*

masculinity. Ann Arbor, MI: The University of Michigan Press.

Gates, H. (1984) *The Signifying Monkey: A Theory of African American Literary Criticism.* Oxford: Oxford University Press.

Gates, H. (2010). Foreword. In A. Bradley & A. DuBois (Eds.), *The Anthology of Rap* (pp. xxii-xxvii). New Haven, CT: Yale University Press.

Gee, J.P. (1999). *Discourse Analysis: Theory and Method.* London: Routledge.

Gee, J.P., & Clinton, K. (2000). An African American child's science talk: Co-construction of meaning from the perspectives of multiple discourses. In M. Gallego & S. Hollingsworth (Eds.), *What counts as literacy: Challenging the school standard* (pp. 118 – 135). New York: Teachers College University Press.

Ginsburg, H. P. (1997). *Entering the Child's Mind: The clinical interview in psychological research and practice*. New York, NY: Cambridge University Press.

Gustafson, B. (1991). Thinking about sound: Children's changing conceptions. *Qualitative Studies in Education, 4*(3), 203-214.

Gutiérrez, K. (2002). Studying cultural practices in urban learning communities. *Human Development, 45,* 312-321.

Gutiérrez, K. (2008). Developing a sociocritical literacy in third space. *Reading Research Quarterly, 43*(2), 148-164.

Gutiérrez, K., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher, 32*(5), 19-25.

Haberman, M. (1991). The pedagogy of poverty versus good teaching. *Phi Delta*

Kappan, 290-294.

Hammer, D. (2000). Student resources for learning introductory physics. *American Journal of Physics, Physics Education Research Supplement, 68,* S52-S59.

Heath, S. (1989). Oral and literate traditions among Black Americans living in poverty. *American Psychologist, 44*(2), 367-373.

Holzman, M. (2006). *Public education and Black male students: The 2006 state report card.* Schott Educational Inequity Index, Cambridge, MA; The Schott Foundation for PUblic Education.

Howard, T. (2008). Who really cares? The disenfranchisement of African American males in prek-12 schools: A Critical Race Theory perspective. *Teachers College Record, 110*(5), 954-985.

Houle, M., & Barnett, M. (2008). Students' conceptions of sound waves resulting from the enhancement of new technology-enhanced inquiry-based curriculum on urban bird communication. *Journal of Science Education and Technology, 17*(3), 242-251.

Hudicourt-Barnes, J. (2003). The use of argumentation in Haitian Creole science classrooms. *Harvard Educational Review, 73*(1), 1-21.

Keller, E.F. (1983). *A feeling for the organism: The life and work of Barbara McClintock.* New York, NY: W.H. Freeman.

Kozol, J. (2005). *The shame of the nation: The restoration of apartheid schooling in America.* New York, NY: Three Rivers Press.

Kress, G., & van Leeuwen, T. (1996). *Reading images: The grammar of visual*

design. Abingdon, OX: Routledge.

Ladson-Billings, G. (2006). It's not the culture of poverty, it's the poverty of culture: The problem with teacher education. *Anthropology & Education Quarterly, 37*(2), 104-109.

Ladson-Billings, G. (1998). Just what is Critical Race Theory and what's it doing in a nice field like education? *International Journal of Qualitative Studies in Education, 11*(1), 7-24.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491.

Lautrey, J., & Mazens, K. (2004). Is children's naive knowledge consistent? A comparison of the concepts of sound and heat. *Learning and Instruction, 14*(4), 399-423.

Lee, C.D. (1995). Signifying as a scaffold for literacy interpretation. *Journal of Black Psychology, 21*(4), 357-381.

Lee, C.D. (2000). Signifying in the zone of proximal development. In C.D. Lee & P. Smagorinsky (Eds.), *Vygotskian Perspectives on Literacy Research: Constructing Meaning through Collaborative Inquiry* (pp. 191-225). Cambridge: Cambridge University Press.

Lee, C.D. (2001). Is October Brown Chinese? A cultural modeling activity system for underachieving students. *American Educational Research Journal, 38*(1), 97-141.

Lee, C.D. (2003). Why we need to re-think race and ethnicity in educational research. *Educational Researcher, 32*(5), 3-5.

Lee, O., Fradd, S., & Sutman, F. (1995). Science knowledge and cognitive strategy use among culturally and linguistically diverse students. *Journal of Research in Science Teaching, 32*(8), 797-816.

Lehrer, R., & Pritchard, C. (2002). Symbolizing space into being. In K. Gravemeijer, R. Lehrer, B. van Oers, and L. Verschaffel (Eds.), *Symbolizing, modeling, and tool use in mathematics education* (pp. 59 – 86). Netherlands: Kluwer Academic Publishers.

Leinhardt, G., Zaslavsky, O., & Stein, M. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. *Review of Educational Research, 60*(1), 37-42.

Lemke, J. (1998). Multiplying meaning: Visual and verbal semiotics in scientific text. In J.R. Martin & R. Veel (Eds.), *Reading science: Critical and functional perspectives on discourse of science* (pp. 87-113). London: Routledge.

Levine, S., & Johnstone, L. (2000). *The science of sound and music.* New York, NY: Sterling Publishing Co., Inc.

Linder, C. (1992). Understanding sound: So what is the problem? *Physics Education, 27, 2*58-264.

Lowe, R. (2000). Visual literacy in science and technology education. *UNESCO International Science, Technology, & Environmental Education Newsletter, XXV*(2), 1-2.

Lymer, G. (2009). Demonstrating professional vision: The work of critique in architectural education. *Mind, Culture, & Activity, 16,* 145-171.

Lynn, M., Bacon, J.N., Totten, T., Bridges, T., & Jennings, M. (2010). Examining teachers' beliefs about African American male students in a low-performing high school in an African American school district. *Teachers College Record, 112*(1), 289-330.

Martin, D. (2009). Researching race in mathematics education. *Teachers College Record, 111*(2), 295-338.

Martin, D. (2006). Mathematics learning and participation in the African American context: The co-construction of identity in two intersecting realms of experience. In N. Nasir & P. Cobb (Eds.), *Improving access to mathematics* (pp. 146-158). New York: Teachers College Press.

Mazens, K., & Lautrey, J. (2003). Conceptual change in physics: Children's naive representations of sound. *Cognitive Development, 18*(2), 159-176.

McDonald, S. (1999). "Exploring the process of inference generation in sarcasm: A review of normal and clinical studies." *Brain and Language, 68,* 486-506.

McMillian, M. (2004). Is No Child Left Behind 'wise schooling' for African American male students? *The High School Journal, 87*(2), 25-33.

Melles, G. (2008). Producing fact, affect and identity in architecture critiques – A discourse analysis of student and faculty discourse interaction. *Art, Design, & Communication in Higher Education, 6*(3), 159-171.

Mitchell-Kernan, C. (1977). Signifying. In A. Dundes (Ed.), *Mother Wit From the Laughing Barrel: Readings in the Interpretation of Afro-American Folklore* (pp. 310-328). Jackson, MS: University Press of Mississippi.

Mitchell-Kernan, C. (1999). Signifying, loud-talking, and marking. In G.D.

Caponi (Ed.), *Signifyin(g), Sanctifyin', & Slam Dunking: A Reader in African American Expressive Culture* (pp. 309-330). Amherst, MA: University of Massachusetts Press.

Moje, E., Collazo, T., Carrillo, R., & Marx, R. (2001). "Maestro, what is quality?": Language, literacy, and discourse in project-based science. *Journal of Research in Science Teaching, 38*(4), 469-498.

Moses, R., & Cobb, C. (2001). *Radical Equations: Civil rights from Mississippi to the Algebra Project.* Boston, MA: Beacon Press.

Nasir, N. (2000). "Points ain't everything:" Emergent goals and average and percent understandings in the play of basketball among African American students. *Anthropology & Education Quarterly, 31*(3), 283-305.

Nasir, N. (2002). Identity, goals, and learning: Mathematics in cultural practice. *Mathematical Thinking and Learning, 4*(2&3), 213-247.

Nasir, N. (2005). Individual cognitive structuring and the sociocultural context: Strategy shifts in the game of dominoes. *The Journal of the Learning Sciences, 14I1), 5-34.*

Nasir, N., Rosebery, A., Warren, B., & Lee, C.D. (2006). Learning as a cultural process: Achieving equity through diversity. In R.K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 489-504).

Noguera, P. (2003). The trouble with Black boys: The role and influence of environmental and cultural factors on the academic performance on African American males. *Urban Education, 38*(4), 431-459.

Ochs, E., Gonzales, P., & Jacoby, S. (1996). "When I come down I'm in the

domain": Grammar and graphic representation in the interpretive activity of physicists. In E. Ochs, E. Schegloff, & S. Thompson, *Interaction and Grammar* (pp. 328-369). Cambridge: Cambridge University Press.

Ogonowski, M. (2008). Encouraging students' imagination. In A. Rosebery & B. Warren (Eds.), *Teaching science to English language learners: Building on students' strengths* (pp. 31-38). Arlington, VA: National Science Teachers Association Press.

Parker, B. (2009). *Good vibrations: The physics of music.* Baltimore, MD: The Johns Hopkins University Press.

Pérez, T. (2010, September). Speech presented at the Civil rights and school discipline: Addressing disparities to ensure equal educational opportunities conference, Washington, D.C.

Rizzuto, M. (2008). A teacher's perspective: What is equity in science education. In A. Rosebery & B. Warren (eds.), *Teaching science to English language learners: Building on students' strengths* (pp. 147-150). Arlington, VA: National Science Teachers Association Press.

Rogoff, B. (2003). *The cultural nature of human development.* New York: Oxford University Press.

Rosebery, A., Ogonowski, M., DiSchino, M., & Warren, B. (2010). "The coat traps all your body heat:" Heterogeneity as fundamental to learning. *The Journal of the Learning Sciences, 19*(3), 322-357.

Roth, W.M. (1996). Learning to talk engineering design: Results from an

interpretive study in a grade 4/5 classroom. *International Journal of Technology and Design Education, 6,* 107-135.

Roth, W.M., & Bowen, G.M. (2001). Professionals read graphs: A semiotic analysis. *Journal for Research in Mathematics Education, 32*(2), 159-194.

Roth, W.M., Pozzer-Ardenghi, L., & Han, J.Y. (2005). *Critical Graphicacy: Understanding visual representation practices in school science. Dordrecht: Springer.*

Saxe, G. (2005). Studying cognition in flux: A historical treatment of Fu in the shifting structure of Oksapmin mathematics. *Mind, Culture, & Activity, 12*(3&4), 171-225.

Seiler, G. (2001). Reversing the "standard" direction: Science emerging from the lives of African American students. *Journal of Research in Science Teaching, 38*(9), 1000-1014.

Serway, R., & Jewett, J. (2003). *Physics for scientists and engineers.* Belmont, CA: Brooks / Cole.

Serway, R., & Faughn, J. (1998). *College Physics: Fifth Edition.* Philadelphia, PA: Saunders College Publishing.

Shealey, M.W., & Lue, M.S. (2006). Why are all the Black kids in special education? Revisiting the issue of disproportionate representation. *Multicultural Perspectives, 8*(2), 3-9.

Sherin, B. (2000). How students invent representations of motion: A genetic account. *Journal of Mathematical Behavior, 19,* 399-441.

Silk, E., Schunn, C., & Cary, M. (2009). The impact of an engineering design

curriculum on science reasoning in an urban setting. *Journal of Science Education and Technology, 18*(3), 209-223.

Slotta, J., & Chi, M. (2006). Helping students understand challenging topics in science through ontology training. *Cognition and Instruction, 24*(2), 261-289.

Smith, J.P., diSessa, A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences, 3*(2), 115-163.

Smitherman, G. (1977). *Talkin and Testifyin: The Language of Black America.* Detroit, MI: Wayne State University Press.

Smitherman, G. (1999). *Talkin that talk: Language, Culture, and Education in African America.* London: Routledge.

Solórzano, D. (1997). Images and words that wound: Critical Race Theory, racial stereotyping, and teacher education. *Teacher Education Quarterly, 24*(3), 5-19.

Solórzano, D. (2002). Critical Race methodology: Counter-storytelling as an analytical framework for education research. *Qualitative Inquiry, 8*(1), 23-44.

Songer, N., Lee, H.S., & Kam, R. (2002). Technology-rich inquiry science in urban classrooms: What are the barriers to inquiry pedagogy? *Journal of Research in Science Teaching, 39*(2), 128-150.

Spears, A. (2007). African American communicative practices: Improvisation, semantic license, and augmentation. In H.S. Alim & J. Baugh (Eds.), *Talkin*

Black Talk: Language, Education, and Social Change (pp. 100-114). New York, NY: Teachers College Press.

Swanson, D., Cunningham, M., & Spencer, M. (2003). Black males' structural conditions, achievement patterns, normative needs, and "opportunities." *Urban Education, 38*(5), 608-633.

Tate, W. (2001). Science education as a civil right: Urban school and opportunity-to-learn considerations. *Journal of Research in Science Teaching, 38*(9), 1015-1028.

Tate, W. (1997). Critical Race Theory and education: History, theory, and implications. *Review of Research Education, 22,* 195-247.

Treagust, D., Jacobwitz, R., Gallagher, J., & Parker, J. (2001). Using assessment as a guide in teaching and understanding: A case study of a middle school science class learning about sound. *Science Education, 85*(2), 137-157.

U.S. Census Bureau. (2007, January 12). State & County quickfacts: Allegany County, NY. Retrieved April 12, 2008, from http://quickfacts.census.gov.

Warren, B., Ballenger, C., Ogonowski, M., Rosebery, A., & Hudicourt-Barnes, J. (2001). Rethinking diversity in learning science: The logic of everyday sense making. *Journal of Research in Science Teaching, 38*(5), 529-552.

Warren, B., Bang, M. Wright, C., Rosebery, A., Hudicourt-Barnes, J., & Nemirovsky, D. (2008). Learning-in-Practice: Coordinating angles of vision and voice in professional communities. Paper presented at the American Education Research Association Annual Meeting, New York, NY.

Warren, B., & Rosebery, A. (2008). Conclusion: Re-conceptualizing diversity in the science classroom. In A. Rosebery & B. Warren (Eds.), *Teaching science to English language learners: Building on students' strengths* (pp. 187-190). Arlington, VA: National Science Teachers Association Press.

Warren, B., Ogonowski, M., & Pothier, S. (2005). "Everyday" and "Scientific:" Rethinking dichotomies in modes of thinking in science learning. In R. Nemirovsky, A. Rosebery, J. Solomon, & B. Warren (Eds.), *Everyday matters in science and mathematics: Studies of complex classroom events* (pp. 119-148). Mahwah: Lawrence Erlbaum Associates.

White, E. (2004). *site analysis: Diagramming information for architectural design.* Tallahassee, FL: Architectural Media Limited.

Whitrow, G.J. (1972). *The nature of time.* New York, NY: Holt, Rinehart, and Winston.

Wittman, M., Steinberg, R., & Redish, F. (2003). Understanding and affecting student reasoning about sound waves. *International Journal of Science Education, 25*(8), 991-1013.

Wolpert, L., & Richards, A. (1997). *Passionate minds: The inner world of scientists.* London: Oxford University Press.

Wright, C.G. (2009). *" I spread out through the air:" Conceptualizing sound from Darlene's point of view.* Unpublished qualifying paper, Tufts University, Medford, MA.

Yin, R. (1994). *Case study research: Design and methods – Volume 5.* London: Sage Publications.

Zacharia, Z., & Barton, A.C. (2004). Urban middle-school students' attitudes toward a defined science. *Science Education, 88*(2), 197-222.