

“Seeing as Sound Travels Everywhere”: African American Boys Learning to “See” Transmission through the Analysis of Invented Representations

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This study examines the meta-representational competence (MRC) of a group of four middle school African American boys as they explore the scientific phenomenon of sound transmission. Through an approach that foregrounds the boys’ drawings and practices of critiquing their drawings, I highlight the intellectual and representational strengths that this group of boys brought to the task of representational design. By taking a resource-rich view of this group of middle school African American boys, I challenge the deficit thinking that is often associated with African American boys’ practices and engagement. Specifically, this study focuses on the boys’ emerging representational criteria as they critique drawings of sound transmission and how these criteria shape the boys’ representational practices. Findings reveal that this particular group of boys developed and negotiated several representational criteria that were continually revisited through the production and critique of their invented drawings. The emerging representational criteria included an accurate representation of a) the appearance of sound waves, b) the directionality of sound waves, and c) the change in volume over distance, time, and/or through a medium. In addition to continually developing an understanding of scientific representations and how they are used, the boys also developed their understandings of sound transmission through an iterative process of designing representations.

This study examines the meta-representational competence (MRC) of a group of middle school African American boys through their abilities in interpreting and critiquing invented representations of sound transmission. By representations, I call attention to Enyedy’s (2005) description of “the act of highlighting aspects of our experience and communicating them to others and ourselves” (p. 427). This conceptualization of representation makes sense for this particular study, as I examine how children negotiate their previous experiences and knowledge of drawing and sound transmission in order to communicate specific aspects of the scientific phenomena. A focus on MRC explores children’s abilities in selecting, producing, and using representations, as well as critiquing, modifying, and designing new representations (diSessa, 2004). By focusing on this group of African American boys, I am contributing to the growing body of literature in the social sciences and education research that acknowledges the strengths and life experiences of this population to expand our understanding of learning within science

and mathematics. Such research is vital to science education, given the continued positioning of African American boys as “at-risk” within educational research and educational institutions (Ferguson, 2000; Swanson, Cunningham, & Spencer, 2003). African American boys are typically identified and discussed from a deficit lens that includes their perceived community deficiencies, family and cultural limitations, and/or their demonstration of adverse behaviors (Lynn, Bacon, Totten, Bridges, & Jennings, 2003). By taking a resource-rich view of this group of middle school African American boys, I challenge the deficit thinking that is often associated with them.

In addition, I explore and identify the variety of practices that this particular group of Black boys, in this study, utilized in developing a scientific and representational understanding of sound transmission. This exploration focuses on the ways of ‘seeing’ and ‘negotiating’ that these boys brought to the task of producing and interpreting drawings of sound transmission and to what extent these ways of seeing generatively intersect (or not) with the practices utilized within the professional scientific community. Through this study, my objective is to begin to identify the heterogeneous ways of thinking within a science learning environment (Lenke, 2001; Rosebery, Ogonowski, DiSchino, & Warren, 2010) that could potentially lead to generative and meaningful understandings of sound transmission. I argue that this recognition initiates the process of inviting those typically considered as outsiders (Brickhouse, 1994) into the scientific community and begins to address the question: *How do we, as educators and educational researchers, create learning spaces that build upon the diverse intellectual and linguistic strengths that children bring to the classroom?*

A Scientific Sense-Making Approach to Learning to “See”

I draw on the work of Warren, Ogonowski, and Pothier (2005) that conceptualizes scientific sense-making as locating one’s interests, purposes, and values, among other dimensions, in relation to the science content being investigated. Ballenger (1997) suggests that teacher’s recognition of children’s sense-making resources is vital in children’s developing relationship with science as a discipline, thus highlighting the opportunity to focus on identity within a sense-making framework. That is, children’s relationships to science can be a source of comfort or conflict, depending on how much of oneself one is able or allowed to bring to the learning experience. By adhering to this perspective, I position these boys’ representational practices as integral components in the process of understanding learning within a scientific community. This is especially important, as these African American boys are positioned as developers of scientific knowledge and contributors to a scientific community, and not as “other” (Lee, 2004) where their practices would be seen as different or beyond the “norm.”

Exploring Meta-Representational Competence (MRC)

Studies of meta-representational competence (MRC) share a common interest in exploring the exhaustive range of capabilities that students have concerning the production and use of external representations (diSessa & Sherin, 2000). This range of capabilities play a role in students’ abilities to select, produce, and use representations, as well as the ability to critique, modify, and design new representations. MRC studies are deeply-rooted in the premise that students’ intuitive ideas serve as the foundation for developing a deeper understanding of representations, thus making MRC congruent with the resource-rich approach utilized in this

study. Work in MRC looks beyond students' "misconceptions" of producing and interpreting external representations, such as graphs and tables, and privileges their ways of knowing, thinking, and conceptualizing as precursors to deeper scientific and representational understanding. diSessa, Hammer, Sherin, and Kolpakowski (1991) found that 6th grade students, without direct instruction on representations such as graphs, produce representations of motion that resembled conventional disciplinary representations of graphs of speed versus time. Although students did not initially produce conventional representations of graphs, students utilized intuitive ideas in the refining of their representations through a process of production and interpretation along with interaction and critique with their peers. With the goal of expanding the science education community's understanding of learning in science, I utilize MRC as an analytic tool to explore and identify the representational practices of a group of African American boys. Other studies exploring children's meta-representational competence have included several scientific phenomena, including the representation of height in two-dimensional maps (Enyedy, 2005), the representation of motion (Sherin, 2000), and the representation of model and real landscapes (Azevedo, 2000).

Within the framework of meta-representational competence, this study investigates the critical resources (diSessa, 2004) that this particular group of boys brought to the task of representing sound transmission. Focusing on the boys' critical resources would examine the aspects of the representations that children take into account when considering and evaluating a representation. Previous studies (diSessa, 2004; diSessa, Hammer, Shein, & Kolpakowski, 1991; Sherin, 2000) have found that students from various age groups utilized numerous criteria similar to those used by practicing scientists. I use this study as an opportunity to specifically build upon the work of Enyedy (2005) and his examination of how a group of 1st and 2nd graders negotiated the appropriated representation for communicating height in a two-dimensional map. By engaging this particular group of boys, I acknowledge the voices (Dixson & Rosseau, 2006; Ladson-Billings, 2005) of these students and include their experiences in theories that account for the teaching and learning of representational practices in science.

Methods

This study is concerned with four boys' developing representational criteria as they judge and critique the quality of their own and each other's invented representations of sound transmission. I use Nasir's (2000, 2005) work that focuses on emergent goals as a basis to organize my analysis. I focus on the boys' emerging representational criteria in relation to the various aspects of sound transmission that they deem as critical to highlight in their drawings.

Data for this research were collected during Session One of a four-day exploration of sound. This specific session is highlighted because it best illustrates the group's emergent representational criteria, as well as the genesis of group representational norms. Within Session One, the boys shared experiences of listening to sound generated from a tambourine. These shared experiences were used to facilitate group discussions and individual representational practices. The boys engaged in discussion and drawing of the tambourine sound's transmission within three different contexts, including: a) experiencing the sound from within the same room, b) experiencing the sound from an adjacent room, and c) experiencing the sound through a barrier (i.e., a solid wall). The difference between contexts B and C is that in context B the door was open whereas in context C the door was closed. The shared experiences were important in grounding group discussions and the ideas that the boys created through their drawings.

Following each of the experiences with the tambourine’s sound, the boys created a drawing to illustrate their ideas on how the sound would reach their ears. Following the drawing of each experience, the boys engaged in a group and a self-critique of each drawing. For example, after experiencing the sound from within the same room, each boy created a drawing depicting how sound would reach their ears. After completing the drawings, each drawing was displayed to the group for individual analysis. The first boy placed his drawing at the center of the table and the group explained their analysis of what made this particular drawing an accurate or inaccurate representation of sound transmission. This process was followed for each student.

Although the group of boys had a previously established relationship and ways of engaging with each other, I discussed with them the importance of engaging in constructive dialogue during the group critique sessions. I wanted to create a learning environment that was mindful of the boys’ self-esteem and self-worth and respected the boys’ styles of interaction that they developed through their ongoing relationship. In addition, through an informal meeting and consent letter, I informed each boy and his parent(s) that the boys’ work would be displayed and analyzed by the entire group throughout their exploration.

The data used for this analysis were the boys’ first and second drawings and the transcript of the critique session that followed each drawing. Drawing upon Nasir’s (2000, 2005) emergent goals framework, I chronologically analyzed each drawing and critique session to identify the group’s emergent representational criteria and determined how these criteria impacted successive drawings to document the development of a group representational form for sound transmission. For example, analyzing the critique of the first boy’s drawing, I highlight what representational criteria emerged during the group conversation. When analyzing the second boy’s drawing, I use evidence from the critique to illustrate how the previous representational criteria was used to critique this drawing as new criteria emerges because of the affordances that the new drawing provides. This cycle continued for a total of eight drawings.

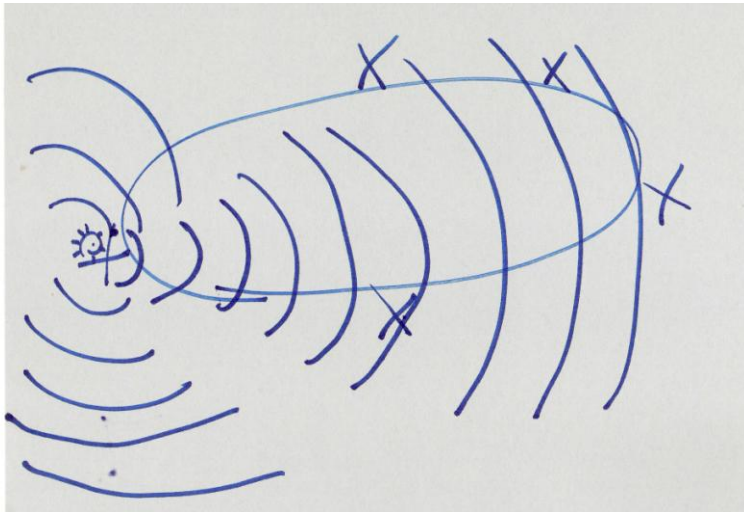
In critiquing the quality of a representation for sound transmission, the boys found that the various aspects of sound transmission being highlighted were deeply interwoven with the decision to represent those aspects in a particular way (i.e., the way you draw it will carry certain meanings). The analysis reveals that the boys’ critique of individual drawings allowed for the emergence of new representational criteria, as well as the boys’ continued interrogation of previously identified criteria. I begin with an analysis of the way each of the four drawings, and the corresponding judgments and critiques, shaped the emergence of the boys’ representational criteria.

Findings

“It’s a lot of waves going everywhere”: Introducing waves and directionality through Earl’s Drawing

After experiencing the tambourine’s sound within the same room, the group of boys were asked to think about and discuss how the sound got from the tambourine to their ears. Following a brief discussion period, the boys represented their ideas through drawings, wherein each boy’s drawing was examined and critiqued during individual critique sessions. Earl’s drawing (See Figure 1) was the first to be analyzed during this period. The boys’ emergent representational criteria and their corresponding aspect of sound were introduced during this analysis.

Figure 1: Earl's 1st drawing of sound transmission



The critique of Earl's drawing began by asking the boys, "what do you notice about Earl's drawing?" The boys' initial exchange is documented in Observation 1.

Observation 1

Floyd: It's a lot of waves going everywhere.

Tim: A lot of waves.

Earl: I'm an artist.

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

Observation 1 introduces initial aspects of sound transmission that the boys identify as important, and their consideration of Earl's representational criteria when highlighting these aspects. For example, Floyd uses his turn to introduce two representational criteria he sees in Earl's drawing: 1) waves are an appropriate way to represent sound and 2) his waves are accurately representing the direction in which sound travels. First, Floyd explicitly names Earl's representation as "waves," which were a primary discussion topic during the boys' discussion of how the tambourine's sound reached them. Next, Floyd describes the waves as "going everywhere." Floyd's observation does not confirm these ideas as essential representational criteria, but does offer the group an opportunity to either accept or reject their importance in evaluating future drawings. The two criteria are implicitly accepted, as Tim also names Earl's representation as "sound waves" and Kenneth noticing that the waves "go everywhere."

Later during the group analysis of Earl's drawing, the boys were asked, "do you all agree with the drawing? Was it a good job at showing sound traveling that way?" Floyd (see Observation 2) uses this opportunity to continue to advocate for accurately representing the direction of traveling waves as a representational criterion.

Observation 2

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

Again, Floyd names Earl’s representations as “waves,” but also explicitly discusses accuracy in the waves’ direction as a current and future representational criteria. I recognize Floyd’s intentions of using directionality as a future representational criterion based upon his comment in Observation 2, *“I don’t think that mine was either.”* This idea is in reference to his drawing of sound transmission that has not been introduced to the group yet, but he still applies this criterion to the future reading of his drawing. Kenneth further validates this representational criterion in Observation 3.

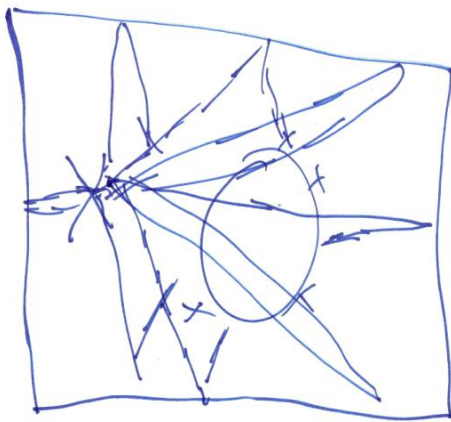
Observation 3

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

“It’s just a bunch of lines”: Emergent Representational Goals and Kenneth’s Drawing

After the analysis of Earl’s drawing, the group was introduced to Kenneth’s drawing (see Figure 2). As Kenneth’s drawing is initially introduced, the boys burst into laughter, however, after a brief reminder of what it means to be respectful of each other’s work, they quickly focused on the task at hand.

Figure 2: Kenneth’s 1st drawing of sound transmission



In Observation 4, Floyd offers his critique upon the introduction of Kenneth’s drawing.

Observation 4

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

Floyd’s comments are important, especially when contrasted with his critique of Earl’s drawing. First, Floyd names Kenneth’s representations as merely “lines.” By naming Earl’s use of crescents (Eshach & Schwartz, 2006) as sound waves and Kenneth’s “scratchy” lines as merely lines, Floyd is pushing for what he perceives as a more accurate way of addressing the emergent criterion of representing the appearance of sound waves. Next, Floyd describes the

lines as going around and bouncing off walls, as opposed to “going everywhere.” Again, Floyd is pushing for a more precise way in addressing the criterion of accurately representing the direction of sound transmission. This is particularly interesting to note because when Earl’s drawing (see Figure 1) and Kenneth’s drawing (see Figure 2) are viewed together, one could argue that Kenneth’s drawing actually depicts sound as “going everywhere.” In Kenneth’s drawing (see Figure 2), he extends a line behind the sound source, as if to represent that the sound can be heard everywhere. In Earl’s drawing (see Figure 1), he does not include a crescent, or wave, behind the sound source, but the boys do not comment on this and Earl’s drawing is the one viewed as accurate.

Kenneth’s drawing is further analyzed based on the representational criteria introduced during the critique of Earl’s drawing. In Observation 5, Earl offers his judgment of Kenneth’s drawing.

Observation 5

Earl: I think he could have made his waves a little bit different. Because it’s just a bunch of lines starting off from where you at. And they’re just going, expanding throughout the room.

Earl’s analysis takes on a different approach than the one offered by Floyd. First, Earl names Kenneth’s representation as both waves and a bunch of lines. In this move, Earl recognizes Kenneth’ attempt to represent “sound waves,” but reiterates Floyd’s emphasis on using a more accurate depiction. In essence, Earl is telling Kenneth, “Yes, I see that you are drawing sound waves, but they are not drawn accurately.” In addition to the appearance of the “waves,” Earl also critiques Kenneth’s drawing for its depiction of the directionality of the sound waves. Similar to Floyd’s description, Earl describes the “waves” as “just going.” The use of *appearance* and *directionality* in critiquing Kenneth’s drawing has further established their role as representational criteria utilized by the boys. It is also important to highlight that emerging criteria were collectively established through the boys’ development of a collegial learning environment. Again, the boys appropriated the concept of a critique session that built upon their communal ways of interacting to foster a positive learning space for all of them to prosper.

“How come it starts off big and gets smaller?”: Floyd’s Drawing

The group was introduced to Floyd’s drawing (see Figure 3) following the critique of Kenneth’s drawing.

Figure 3: Floyd’s 1st drawing of sound transmission



Initially, Floyd’s drawing is evaluated using the representational criteria established during the critique of Earl and Kenneth’s drawings. Observation 6 documents Kenneth’s critique.

Observation 6

Kenneth: Its waves going in all directions; how it should be, except straight forward.

Again, Floyd’s use of the crescent in representing the appearance of sound waves is validated by Kenneth’s naming them as “waves.” In addition, Kenneth addresses the criterion of accurately representing the direction of sound transmission by stating that the sound waves are going in all directions. At the end of Kenneth’s statement, he appears to highlight a critique of Floyd’s drawing by stating, “*except straight forward.*” Facilitating this critique session, I interpreted, and maintain Kenneth’s statement as further validating Floyd’s drawing. I understood Kenneth as meaning to say, “how it should, and not just straight forward,” again highlighting the idea that the drawing provides an accurate representation of sound waves’ directionality. The identification of the appearance and directionality of sound waves originally informed the initial critique of Floyd’s drawing.

Despite the constraints that the previous representational criteria imposed on the critiques of future drawings, Floyd’s drawing afforded the opportunity to introduce another emergent criterion, representing the change in volume of sound using distance, time, and/or space. This aspect of sound refers to how the volume is impacted by distance (i.e., short versus long distances), time (i.e., the duration of a sound), and space (i.e., heard through solid walls or curtains). In Observation 7, the exchange between Earl and Floyd introduces the idea of using this as a new criterion.

Observation 7

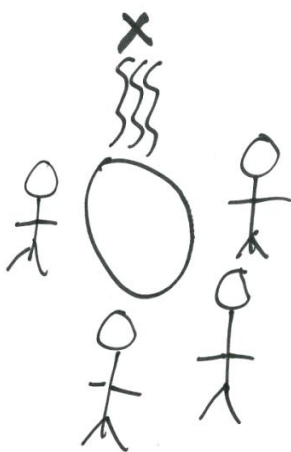
Earl: Floyd, how come it starts off big then when it bounces off the wall, it gets smaller?

Floyd: Oh, because it’s loud right there [where it starts off]. It’s loud when it comes 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 the waves are so big around the tambourine.

Earl could have meant many things with his question, but when coupled with Floyd's interpretation and answer, the idea of representing the change in volume is introduced as a new representational criterion. In analyzing Floyd's drawing, the size of the waves becomes an appropriate way of representing this idea.

"He got stinky lines": Applying all of the emergent goals to Tim's drawing
The final drawing critiqued by the group during this segment was Tim's drawing (see Figure 4).

Figure 4: Tim's 1st drawing of sound transmission



When Tim's drawing was introduced, again, the boys burst into laughter. After the laughter subsides, Floyd offers the first critique, as documented in Observation 8.

Observation 8

Floyd: He got stinky lines on top of him. Saying you stink.

Floyd's critique is directly related to the representational goal of the appearance of sound waves. Again, as utilized during the critique of Kenneth's drawing (see Figure 2), Floyd names Tim's representation as "lines" and not waves, as done with Earl's drawing (see Figure 1) and Floyd's drawing (see Figure 3). I contend that Floyd's use of "lines" is subtly used to reject Tim's representation and establish an appropriate representation for sound waves. Although Tim's "lines" are "wavy," they still do not meet the level of accuracy that Floyd sees and associates with the use of the crescents. By grouping Tim's "lines" with Kenneth's "lines" through the simple practice of naming them "lines," the boys have begun to establish that the crescents, or what they name as "waves," may be the most appropriate device for representing sound waves.

In addition to Floyd's "lines" reference, he also uses his practice of naming symbols as a way to suggest that Tim's symbol is not up to the task of representing sound because he also reads them as smell. Again, by naming Tim's drawing as "stinky lines," Floyd is highlighting

that Tim’s wavy lines do not have a “unique interpretation” (diSessa, 2004) and could also represent smell, therefore permitting the possibility of multiple meanings of Tim’s drawing.

Following Floyd’s comments, Observation 5.9 documents Kenneth’s focus on the other emergent representational goals.

Observation 9

Kenneth: It looks like you [the sound source] wasn’t playing the volume loud at all, because the waves are going nowhere; about two feet in front of you.

Again, Kenneth’s critique of Tim’s drawing utilizes the representational goal of the directionality of sound. Kenneth also uses a subtle use of language to relate Tim’s drawing to previous critiques. Kenneth states, “the waves are going nowhere; about two feet in front of you.” Kenneth contradicts himself by using going nowhere and going two feet within the same sentence, but he is verbally contrasting Tim’s drawing with the representational goal of representing sound as “going everywhere.”

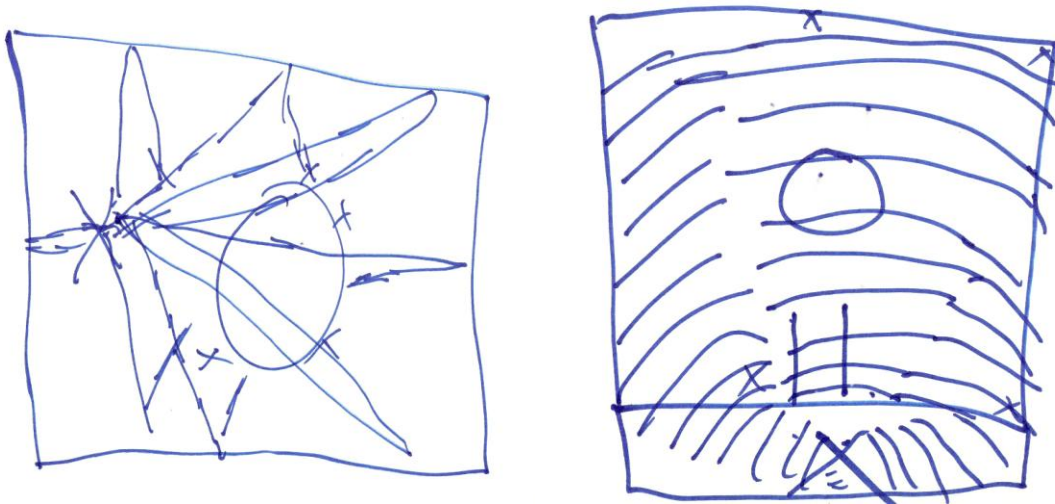
Thus far, this article has identified the emergent representational goals that the boys applied to drawings representing sound transmission. The emergent goals include: 1) use of appropriate symbols for representing the appearance of “waves” (appearance), 2) accurately representing the direction of sound waves travel (directionality), and 3) accurate representation of the change in volume over distance, time, and/or through a medium (volume). The boys’ representational criteria were not pre-determined or established criteria, but collectively constructed through the opportunity to engage in the group critique of four drawings.

Each individual drawing played a unique role in the development of these goals and provided different opportunities to explore the boys’ conceptions of sound transmission. Earl’s drawing served as the introductory drawing for critique and offered the boys the opportunity to “read” the drawing in order to identify the aspects of sound. This is important to note because the remaining three drawings (Floyd’s, Kenneth’s, and Tim’s) were interrogated using different goals; those already established by the previous drawing(s) and any other emerging goals developed by the group (See Table 1). Recognizing that the development of representational goals may have impacted individual drawings differently, I will use the remaining section of this paper to examine how the emergent representational goals impacted the second drawing for each boy.

Appropriating the Emergent Representational Goals

Following the critique of the boys’ first drawings, the group experienced the tambourine’s sound from an adjacent room and engaged in a brief discussion on how the sound got from the tambourine to their ears. Following this discussion, the boys redesigned their drawings of sound transmission through their new experience with the tambourine. After their redesign, each boy was asked to provide the group an analysis of their first and second drawing. Kenneth was the first boy to review his representational practices through his first and second drawings (grouped together in Figure 5)

Figure 5: Comparing Kenneth's 1st and 2nd drawings



Observation 10 illustrates the exchange that revolved around the analysis of Kenneth's drawings.

Observation 10

Interviewer: So, how did your drawing change?

Kenneth: Because that seems like the more appropriate or better way to do it.

Interviewer: Why is that?

Kenneth: Like, it's [the 2nd drawing] easier to understand than that one [the 1st drawing] was.

Interviewer: Okay, so what is this [the 2nd drawing] showing better than this one?

Kenneth: The waves.

Interviewer: The waves. And what about the waves?

Kenneth: These waves just travel, instead of just bouncing off the wall.

In this excerpt, Kenneth recognizes that he has utilized the crescents because they “seemed like the more appropriate way” and that they are easier to understand as waves, thus maintaining his focus on appearance as a representational criterion. In addition, he identifies the representational criterion of directionality by stating that the waves “just travel, instead of bouncing off the wall.” This statement is important because not only has the process of designing representations of sound altered his representational practices, but it had also assisted in his conceptualization of sound transmission (Enyedy, 2005).

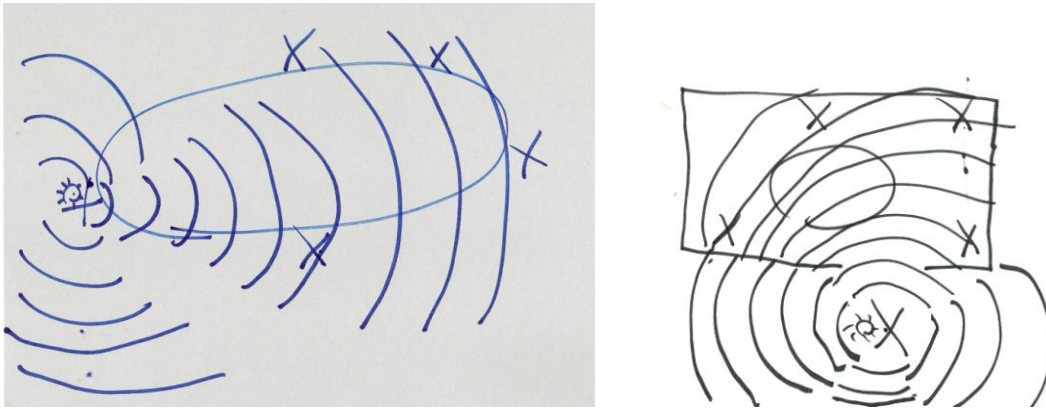
In addition to Kenneth's self-analysis, I provide a brief comparison of the drawings. First, Kenneth also focuses on the representational criterion of sound's directionality by including the crescents behind the sound source (See Figure 6). This was a representational feature that the group did not notice in his first drawing (See Figure 5) because of his use of “just lines.” Although not recognized by Kenneth, I want to discuss the possible inclusion of another emergent criterion: the quantity of sound waves. In Kenneth's first drawing, he used eight different “lines” to represent sound transmission, while he only used 3 different “waves” in his

second drawing. I hypothesize that his changing conception of how sound travels (i.e., “they just travel instead of bouncing off the wall) contributed to this new feature in his drawing.

Earl’s Self-Analysis

After Kenneth’s self-analysis, Earl was afforded the opportunity to discuss the changes from his first to second drawing (grouped in Figure 6).

Figure 6. Comparing Earl’s 1st and 2nd drawings



During his self-analysis, Earl focuses on the emergent representational criterion of accurately representing the change in volume over a distance. Observation 11 instantiates his analysis:

Observation 11

Earl: They’re [the waves] saying in this one [See Figure 7], it got louder and louder. But when it [the waves] got to me, it was loud. But in this one [See Figure 8], as it [the waves] got to me, the sound got lower.

In Observation 11, although Earl focuses on the goal of accurately representing the change in volume over distance, he acknowledges that the representational features remain the same. The primary change for Earl is the meaning of the “waves.” In the first drawing the increasing waves meant the volume increasing while in the second drawing the increasing waves meant the decreasing of the volume. The increasing wave size in drawing on the right side in Figure 6 illustrated the sound as getting louder, while the drawing on the left side in Figure 6 illustrated the sound getting quieter. I suggest that Earl’s re-conceptualization of his representation was informed by a previous analysis provided by Floyd, as seen in Observation 12.

Observation 12

Floyd: Because, mine’s, the bigger the lines, the more space the sound has to spread out. When that happens, when they spread out, it’s not as concentrated as like right around you. So, I’ll say the bigger the lines, the less the sound is.

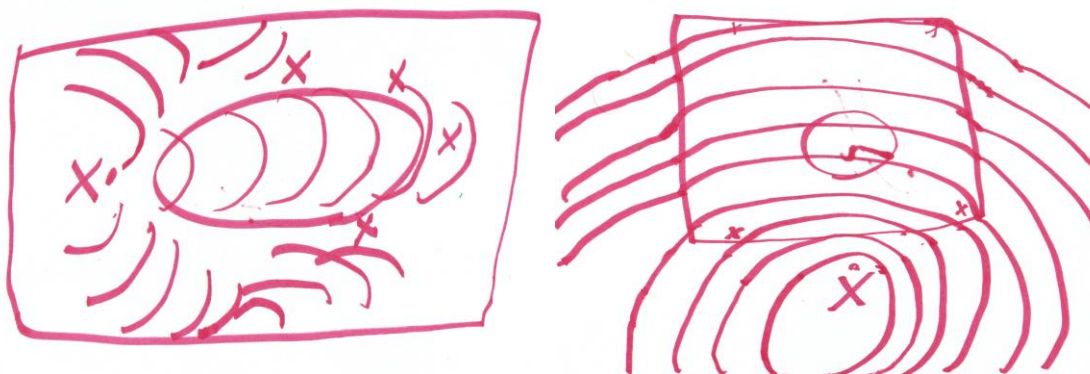
I hypothesize that the conversation around Floyd’s assertion informed Earl’s “new meaning” for the increasing sound waves. In addition to Earl’s change in meaning, I recognize that Earl appropriated the representational criterion of directionality by enclosing the sound

source (See the “X” as the tambourine in right side of Figure 6) with sound waves. His first drawing (See left drawing in Figure 6) was interpreted as “going everywhere,” but did not include a “wave” behind the sound source.

“It’s not just contained in the room”: Floyd’s Self-Analysis

Following Earl’s analysis, Floyd provided an analysis of his first two drawings (grouped in Figure 7).

Figure 7. Comparing Floyd’s 1st and 2nd drawings



In Observation 13, Floyd expresses his reasons for altering the representational features in Figure 7.

Observation 13

Floyd: Because, at first [See Figure 7] I made it seem like air wasn’t surrounding you. The center of the waves wasn’t surrounding you. And they [the sound waves] bouncing off the walls in my first one. But, in my second one [See Figure 7], I just made it [the sound waves] go everywhere, because I think you could hear the noise outside the room too. It’s not just contained in the room. That’s why the ones 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.

Floyd includes a lot of information within this excerpt. First, he addresses his attunement to the representational criterion of directionality in two instances. Initially, he incorporates features that display sound as surrounding the sound source. Next, he made the sound waves “just go everywhere” instead of “bouncing off the walls.” As mentioned in relation to Kenneth, Floyd’s conceptualization of the representation is not the only thing that has been altered through this iterative process. I suggest that his conceptions of sound transmission, in general, have also developed. He no longer believes that sound needs to “bounce off of walls” to reach everyone in the room, instead the waves “just go everywhere.” To further this point, I also highlight Floyd’s use of “one wave” in Figure 7 (See the drawing on the right), as opposed to the three separate waves that he incorporates in Figure 7 (See the drawing on the left). I contend that in Figure 7 (See the drawing on the right), Floyd conceptualizes sound as needing three separate waves that

bounce off of the walls to reach every person in the room. An analysis of individual drawings and group discussions may have altered this perception, as illustrated in Figure 7.

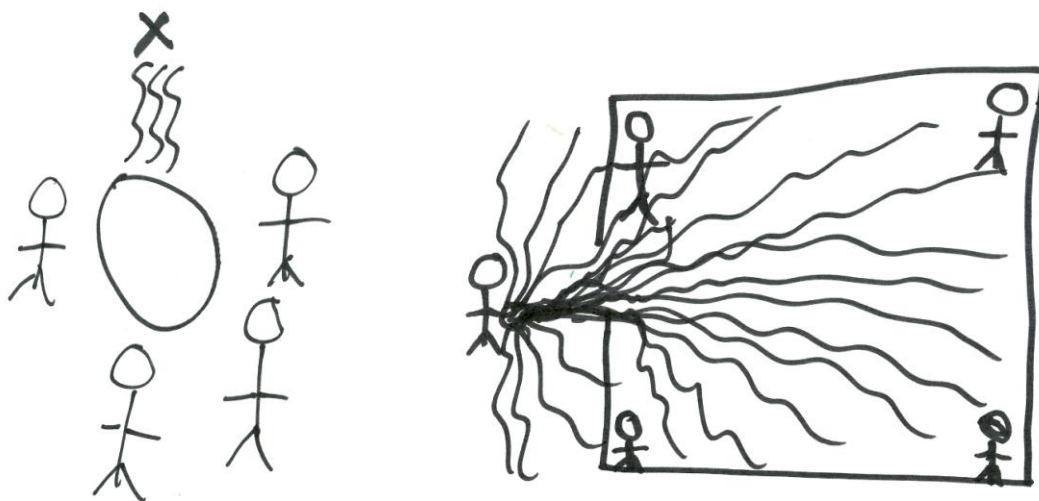
Next, Floyd also illustrates his attunement to the representational criterion of accurately representing the change in volume over distance. He reiterates his representational meaning of increasing waves illustrating a decrease in volume. Floyd also introduces another aspect involved in the change of volume, a barrier or the solid wall in this instance. Not only illustrating that volume decreases over distance, but he also illustrates and points out his belief in sound waves to penetrate other areas by stating, “it’s not just contained in the room. That’s why the ones outside the room is like the biggest.” Again, through this process of critiquing and analyzing drawings, Floyd’s understanding of sound is also impacted.

Analyzing Tim’s Drawings

Although Tim could not provide verbal explanation concerning the changes in his drawings, I noticed several representational adjustments between his first drawing and his second drawing (grouped in Figure 8).

I noticed that Tim utilizes two of the emergent representational criteria: directionality and the change in volume over distance. Figure 8 displays Tim’s attunement to directionality by the “spreading” of the sound waves. In contrast to Tim’s initial drawing, his second drawing represents sound going in multiple directions. Although he did include sound waves behind the sound source, he still adjusted his representational features based on the established representational criteria of the group. Despite Tim’s adjustment, Kenneth’s critique in Observation 14 highlights that Tim has not addressed all of the criteria established by the group.

Figure 8. Comparing Tim’s 1st and 2nd drawing



Observation 14

Kenneth: Well, I don’t really understand his because you can’t tell where it gets higher or lower [the volume] or further of closer away.

In this instance, Kenneth is highlighting that Tim still needs to design a more appropriate way of illustrating the change in volume over distance.

Conclusion

Research examining the educational experiences of African American children, particularly boys, often begins with questions of why they do so poorly, drop out at such high rates or how to close the academic achievement gap by developing strategies for teaching this population of children (Silk, Schunn, & Cary, 2009). This study is a counter-narrative to the research and instructional goals that often serve to stigmatize and undermine the intellectual capacity of African American boys. Challenging approaches that utilize a deficit lens, this study illustrates how research and instruction can be built upon the intellectual strengths that African American boys bring to the study of science. Without any formal instruction in the design of “scientific representations,” these middle school boys collectively identified a set of criteria for developing appropriate drawings for sound transmission while at the same time they demonstrated their representational strengths for the task of representational design and critique. Through this exploration and the iterative design process, the boys not only developed their understanding of representing scientific phenomena, but also expanded their understandings of the phenomena itself.

A scientific sense-making approach to exploring the boys’ representational strengths also allowed the boys to bring their ways of knowing and being into an academic setting. Within this approach, the boy’ thoughts and ideas (presented through their drawings and critiques) were utilized as the focus for group learning, not a science textbook. The boys displayed the abilities to construct scientific and representational understanding through an iterative process of theory building, criticism, and refinement around their invented representations of sound transmission. I do not claim that these boys are “expert” designers of representations or possess a fully developed understanding of sound transmission, but I do argue that the approach presented here could possibly promote more engagement with these areas. Creating a “scientific sense-making community” that engaged the boys in sharing thoughts and observations, defending design decisions, and negotiating the meaning of their drawings positioned these boys as developers of scientific knowledge. Based upon the findings put forth in this study, I challenge educators and educational researchers to think about how we develop learning environments that serve as generative and engaging spaces that attract students from populations that have been historically underrepresented in science.

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