Drama Activities as Ideational Resources for Primary-Grade Children in Urban Science Classrooms

Maria Varelas,1 Christine C. Pappas,1 Eli Tucker-Raymond,2 Justine Kane,1 Jennifer Hankes,3 Ibet Ortiz,3 Neveen Keblawe-Shamah3

1University of Illinois at Chicago, Chicago, Illinois
2TERC, Cambridge, Massachusetts
3Chicago Public Schools, Chicago, Illinois

Received 3 June 2009; Accepted 24 July 2009

Abstract: In this study we explored how dramatic enactments of scientific phenomena and concepts mediate children’s learning of scientific meanings along material, social, and representational dimensions. These drama activities were part of two integrated science-literacy units, Matter and Forest, which we developed and implemented in six urban primary-school (grades 1st–3rd) classrooms. We examine and discuss the possibilities and challenges that arise as children and teachers engaged in scientific knowing through such experiences. We use Halliday’s (1978. Language as social semiotic: The social interpretation of language and meaning. Baltimore, MD: University Park Press) three metafunctions of communicative activity—ideational, interpersonal, and textual—to map out the place of the multimodal drama genre in elementary urban school science classrooms of young children. As the children talked, moved, gestured, and positioned themselves in space, they constructed and shared meanings with their peers and their teachers as they enacted their roles. Through their bodies they negotiated ambiguity and re-articulated understandings, thus marking this embodied meaning making as a powerful way to engage with science. Furthermore, children’s whole bodies became central, explicit tools used to accomplish the goal of representing this imaginary scientific world, as their teachers helped them differentiate it from the real world of the model they were enacting. Their bodies operated on multiple mediated levels: as material objects that moved through space, as social objects that negotiated classroom relationships and rules, and as metaphorical entities that stood for water molecules in different states of matter or for plants, animals, or non-living entities in a forest food web. Children simultaneously negotiated meanings across all of these levels, and in doing so, acted out improvisational drama as they thought and talked science. © 2009 Wiley Periodicals, Inc. J Res Sci Teach 47: 302–325, 2010

Keywords: language and literacy; language of science and classrooms; social construction; urban education; science education

We explore young children’s ways of developing and communicating scientific understandings through their engagement in drama activities that were part of two integrated science-literacy units, Matter and Forest, which we developed and implemented in urban school classrooms. We examine six ethno-linguistically diverse primary-grade classrooms to determine how children and their teachers drew upon, developed, and expressed scientific ideas as they enacted the drama activities. As part of the Matter unit, children acted out molecules in the three states of matter: solids, liquids, and gases; in the Forest unit, children acted out animals, plants, and inanimate objects as part of a food web in a temperate forest. We study how dramatic
enactments mediate and are mediated by scientific meanings along material, social, and representational dimensions.

Theoretical Framework

Modeling and Multimodality

In the science education field, a significant body of research exists related to models and modeling and their role in learning science. Models are representations of phenomena, objects, events, ideas, and systems (Gilbert & Boulter, 2000). They reflect the parts and structures of a system to be explored and understood, as well as the functions of these structures and their interrelationships. As such, “Models serve as conjectures, explanations, didactic devices and communication vehicles” (Mathewson, 2005, p. 533). Models and modeling have played an important role in the history and development of science and they have been used and studied in classrooms aiming at improving science teaching and learning.

Over the past three decades, there has been accumulating evidence on the role of models, analogies, and metaphors in science learning and teaching, underscoring their advantages to visualize abstract ideas, link thinking with feeling, support conceptual learning and comprehension, and increase motivation (Coll, France, & Taylor, 2005). However, research has also identified challenges associated with modeling that center on (1) differences (surface and higher-order) between a model and the phenomenon that it represents, and (2) students’ varying level of familiarity with the analog domain of the model, both of which may compromise the usefulness of modeling.

Models may be expressed in various modes—action, speech, writing, or other symbolic forms—and can be clustered in various categories, such as “descriptive (verbal, graphic, tabular), experimental, mathematical, figurative (pictorial, analogous and metaphoric), and kinesthetic or embodied gestural understandings or representations of...[a] concept or process” (Prain & Waldrip, 2006, p. 1844). Although oral and written language are dominant modalities of expressing and developing meaning in science classrooms, models and modeling offer learners opportunities to also engage with two- and three-dimensional representations of scientific entities in space and time. Such representations include visual, auditory, and/or kinesthetic symbol systems that facilitate meaning making and complement the verbal symbol systems of talking and writing that are so prevalent in classroom practice (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001; Roth, 2004). These non-linguistic symbol systems may include static images, physical objects in the field of vision, human-body movement and expressions, and sound effects.

The different semiotic modes in which models may be expressed offer different affordances for the development and communication of different kinds of meanings (Jewitt & Kress, 2003; Kress & van Leeuwen, 1996, 2006). Multiple modalities have been an interest of research in fields such as anthropology for more than seventy years (Erickson, 2004); however, recognition of their importance in educational practice and research is only recently gaining a wider currency (Cope & Kalantzis, 2000). Considering learning as a process mediated through various material and symbolic spaces, artifacts, and activities (Roth, 2005) particularly nurtures such an emphasis on multimodality and exploration of its role in improving understanding of, and engagement with, ideas.

In this study, we explored the modes realized in a particular type of modeling, namely dramatizing of scientific ideas (which in our case are molecular behavior and relationships among living and non-living entities in a temperate forest ecosystem). The dramatizing took place in the context of integrated science-literacy units we have designed that engage children in a range of multimodal activities. In addition to dramatizing, the units engage children in reading children’s literature illustrated information books and composing their own, performing and discussing hands-on explorations, keeping an illustrated science journal, and producing class murals using various materials. Such activities capitalize on students’ abilities and preferences to develop and express their understandings in a range of ways.

Using Drama in Learning Science

Turner and Bruner (1986) claim that performing arts, like theater, help fill in gaps in meaning. People use their experiences to mediate and understand their participation in drama and drama helps people mediate and understand their experiences in the world. In dramatizing, children’s experiences with constructs and entities
of the curriculum are mediated by and mediate their enactments of the drama. That is, what children learn in a
drama has to do with what they already know about the subject, but at the same time, it contributes to that
knowledge. Thus, classroom drama activities are a unique kind of semiotic tool where meaning is expressed
and developed simultaneously in visual-spatial-kinesthetic and linguistic modes of communication. In spite
of successful use in language arts, reading, and social studies, drama has not been used widely in science
teaching and learning (Alrutz, 2004).

The science drama activities we developed and enacted in classrooms constitute a particular curriculum
genre that shares certain characteristics of drama as an art form (Pappas & Zecker, 2001a,b). Across both
units, in these activities children acted out a role. They enacted representations within some general
guidelines that their teacher laid out or co-constructed with them. Although it might be argued that children
play the roles of students in classrooms everyday according to guidelines about what it means to go to school
(Schank & Abelson, 1977), what makes these activities drama is that children enacted representations of the
scientific content knowledge they were supposed to be learning. That is, they engaged with others as actors
(molecules or forest entities) who were part of a larger goal-directed scene (water changing states of matter or
interacting entities of a food web) that was aimed at mediating and transforming their understanding of the
scientific concepts they were becoming. In other activities, children enacted scientific practices, in that they
observed phenomena, recorded data, developed explanations, and so forth, but they did so as themselves, as
students. In the drama activities, children were asked to become “the things” they were learning.

These drama activities were like “process drama,” “a mode of learning” that allows learners to use
imagined roles to “explore issues, events, and relationships” (O’Neill & Lambert, 1983, p. 11), where there is
no a priori detailed script (Schneider, Crumpler, & Rogers, 2006). They were improvisational drama in which
the actors became in part co-playwrights and co-directors, deciding and enacting what to do and how, and
using audience suggestions to guide their performance (Weltsek-Medina, 2007). This participatory process
not only generates fun, but also creativity, thinking, and imagination.

In some ways, dramatic enactments of scientific ideas enable children to do a kind of “imagining” in
science (Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001) that they may not do with
language alone. Warren et al. define imagining as “inhabiting a created world to explore what might happen
or how something might react” (p. 544). Imagining requires “playing around” with what representations
would look like, what they would mean, and why. When children use their bodies to imagine how molecules
move and bond to each other in different states of matter or how animals, plants, and inanimate entities relate
to each other in a forest community, they spend time on concepts, constructing and representing contrasts
between them and other concepts. They have to think about what makes each concept unique, which ones are
related, and which are not. This promotes children’s engagement with the sign–sign dimension of thinking
and learning (Becker & Varelas, 1993; Varelas & Becker, 1997), where ideas and concepts are linked with
each other in the context of a network of other related ideas. A strong and meaningful network is formed as
differentiation among concepts leads to further coordination that, in turn, enriches understanding and
strengthens the meaning of these concepts and ideas.

Moreover, dramatizing creates hybrid spaces where students bring into the classroom their own
everyday funds of knowledge and Discourses that scholars have linked with increased participation and
learning for students in urban settings (Moje et al., 2004; Barton & Tan, 2009). As drama activities are
enacted, conversational spaces develop, defined by traces of multiple discourses (Bakhtin, 1981) that come
together as everyday and scientific ways of thinking, communicating, and acting become interwoven with
each other. The participatory-interactive structures that are nurtured in dramatizing may be particularly
beneficial to students of color, such as African American students whose life experiences may incorporate the
Black Cultural Ethos (BCE) (Boykin, 1986; Nobles, 1980). School contexts that incorporate features of BCE,
such as sociality, movement, and variability, have been associated with higher achievement of African
American students (Parsons, 2008).

Furthermore, as Winner (1982) wrote: “Both producing and perceiving art require the ability to process
and manipulate symbols and to make extremely subtle discriminations... the arts are viewed as fundamental
ways of knowing the world” (p. 12). Art is not only a mode to express feelings and emotions, but it is also
cognitive—it fosters in students flexible, creative ways to think about and depict meaning (Efland, 2002).
The Nature of Drama

Dramatizing is different in significant ways from other types of modeling, including creating 3D representations. During drama, people create imaginary worlds that allow them to link their own experiences with the unknown, or outer, social world (Henry, 2000). As these links are established, actors move back and forth between the actual and imaginary worlds. The dramatic enactments allow them to use specific perspectives to see the world, perspectives they have not used in real life. Bolton (1984) called this state of belonging to two different worlds, the world of image and the world of reality, metaxis.

During metaxis, learning occurs at multiple levels. The performed meaning (Geertz, 1973) that actors develop and express unfolds in the cross-section of the two worlds that the actors live in during the drama, which, in turn, constitutes a particular form of meaning. The goal of this study was to explore such performed meaning in classroom drama activities that offered children opportunities to create, and temporarily live in, and in-between, imagined and real worlds of science, the world of molecules and the world of forest animals and plants.

Furthermore, each enactment occurred within the setting of the classroom and school, which means that children’s participation was governed by particular norms. Thus, children’s involvement in the drama activities was not only shaped by the scientific concepts and affordances of dramatic representation, but was also influenced and shaped by the affordances of spatial arrangement and conventional practice of the settings they were in and in the ways they knew that they were allowed to operate in such settings. Thus, this study explored the ways in which physical, material, and social arrangements of the schooled settings where drama took place mediated the dramatic enactments and the scientific ideas that the children represented.

The classrooms differed in their physical layouts, in the ways that the teachers introduced, participated in, and gave directions for the dramas, as well as the nature of the two drama activities. Bakhtin’s “chronotopes” (1981) offers a useful tool to conceptualize the synergy between time and space that defined the experience of children in both worlds that the drama activities involved—the real world where the children lived, and the pretend world that they were enacting during the drama. Bakhtin used the term “chronotopes” to denote the units of time and space where narratives unfold—“the chronotope is where the knots of narrative are tied and untied” (p. 251). He associated chronotopes with meanings that are developed as readers engage with narratives, and he claimed that it is through the chronotopes that meanings are achieved. Chronotopes are ways of bringing together the world of the author, the performer, and the world of the reader, the audience. Bakhtin wrote:

Therefore we may call this world the world that creates the text, for its aspects—the reality reflected in the text, the authors creating the text, the performers of the text (if they exist) and finally the listeners or readers who recreate and in so doing renew the text—participate equally in the creation of the represented world of the text. Out of the actual chronotopes of our world (which serve as the source of representation) emerge the reflected and created chronotopes of the world represented in the work (in the text). (p. 253)

The drama activity is a visual narrative of a phenomenon, its major parts and how they connect to each other, a sequence of events and how they unfold, and how change occurs over time in the depiction of the phenomenon. Applying Bakhtin’s ideas to the drama activity, we attend to the ways time and space came together for the children as they found themselves both in the imaginary world of molecules or forest entities they were enacting and in the real world of their classrooms populated by classroom objects, peers, and their teacher.

Consistent with the Bakhtinian notion of chronotopes, and the spatial and temporal relationships that are important to consider in language and any literary image, are Halliday’s (1978) three metafunctions of language that have been extended to other modalities by Jewitt and Kress (2003), and Kress and van Leeuwen (2001, 2006). These functions are: the “ideational” function (constructing and representing characteristics and processes of the world around us); the “interpersonal” function (constructing and enacting social interactions between people as they engage with ideas); and the “textual” function (constructing the drama activity as a recognizable, coherent multimodal text expressing ideas).
Defining “texts” in an expansive form to include artifacts that represent ideas expressed in visual, auditory, and/or kinesthetic forms, we use these three metafunctions as an analytical tool to explore the possibilities and challenges that drama activities offered our young children. Drama constitutes a semiotic system with multimodal texts that realize particular affordances for meaning making, and, as all texts, are influenced, as well as influence, the context—the physical, social, material, and human environment in which they are enacted. As Halliday and Hasan (1989) noted, “the relationship between text and context is a dialectical one: the text creates the context as much as the context creates the text. ‘Meaning’ arises from the friction between the two” (p. 47).

Research Goal

In this study we explore how dramatic enactments of scientific constructs, ideas, and phenomena mediate and are mediated by scientific understandings and everyday knowledge along material, social, and representational dimensions. We use the three metafunctions of communicative activity—ideational, interpersonal, and textual—to map out a potential place of the drama genre in elementary urban school science classrooms of young children. In doing so, we examine and discuss the possibilities and challenges that arise as children and teachers engaged in scientific knowing through such experiences.

What underlies our analysis is an assumption that emotion, feelings, and affect are integrally intertwined with reasoning, thinking, cognizing, and interacting with others (Varelas, Becker, Luster, & Wenzel, 2002). That is, as we attempt to understand the ways drama activities engage children with scientific ideas and become ideational (and interpersonal and textual, as described above) resources for them, we keep in mind that these activities may also be, at the same time, affective resources that offer children and teachers opportunities to feel and express such emotions as happiness, surprise, anger, sadness, disappointment, excitement, joy, satisfaction, anxiety, or guilt. Our goal in this study is not to detangle affect from thinking and communicating, but rather to fold it into our interpretations of how drama activities “play out” in urban primary-grade science classrooms.

Furthermore, in this study our goal was to explore the “togetherness” of dramatizing, how children’s and their teacher’s ideas and contributions in a particular classroom came together and shaped the meanings created during dramatizing. We did not address individual children’s understandings and participation in the drama activities, but rather how ideas, actions, behaviors, and emotions were collectively enacted, developed, and transformed. In this way, we aim at contributing to the scant literature of studies in urban elementary school classrooms that help us understand the complex and nuanced workings of classroom learning and teaching (Varelas, Kane, Tucker-Raymond, & Pappas, in press).

Method

Participants and Settings

The drama activities we explored in this study took place in six primary-grade classrooms in public schools in a large Midwestern city, two classrooms in each of three grades, 1st, 2nd, and 3rd grade. Six teachers across five schools participated in a collaborative school-university research project, called Integrated Science-Literacy Enactments (ISLE), a partnership that aims to explore various dimensions of integrated science-literacy teaching and learning. Two classrooms—Ibett Ortiz’s 2nd grade and Neveen Shamah’s 3rd grade at the same school—were 100% Latino/a with the 2nd grade being a bilingual class where instruction was conducted in Spanish and English. Additionally, one of the first grades classrooms, Anne Barry’s, was predominately Latino/a, one 3rd grade classroom, Jennifer Hankes’ was 100% African-American, and the other two classrooms—Sharon Gill’s 1st grade and Begoña Cowan’s 2nd grade—had children from diverse ethnolinguistic backgrounds. Only these two diverse classrooms had on the average about 50% of their children in free or reduced lunches, whereas the children in the other four classrooms were almost entirely on free or reduced lunches.

In the Molecule drama activity in the Matter unit, students move their bodies through different-sized spaces at different speeds in different kinds of relationships to their fellow classmates. As a solid they move slowly, minimally within the small ice cube marked out via masking tape on the floor, which is placed in a large masking-tape cup, while they are locked at the elbow, heads pressed together in an intimate huddle. As a liquid they still hold hands, expanding to the edges of the cup in which the ice cube is held, but they move
faster and looser. As a gas they separate and run around the whole classroom forcing the teacher to close the classroom door so that they do not escape.

A few clarifying notes are in order here. First, in the Matter unit, children explore the three states of matter (solids, liquids, gases)—their characteristics and examples of everyday substances in each of these states, changes of states, such as freezing, melting, evaporation, and condensation, and the water cycle (Varelas, Pappas, Kokkino, & Ortiz, 2008). The focus we have brought to this unit is often seen as unconventional. For grades K-3, the National Science Education Standards (National Research Council, 1996) recommend the development of young children’s observational skills and abilities to notice and describe patterns in data. Not until the middle grades are children asked to theorize, engage with ideas, generate interpretations, and develop explanations/conceptions about how the world works. However, science is the “dance” between data and ways of understanding data (Varelas, 1996), and, thus, young, early-elementary-grade children must be given opportunities to engage in both observing and experimenting, and in developing ways to explain what is going on in the world, even though they may not be ready to develop sophisticated ways of thinking and talking about some science topics. Therefore, in this unit, we introduce the students to the idea that matter consists of molecules that “behave” differently in different states—an idea that explains the macroscopic characteristics of different states.

Second, we do not discuss that water is an exception to the behavior of most substances when they change from solid to liquid, in that water contracts (i.e., its molecules come closer together) instead of expanding when it melts. Thus, in the Molecule drama, children acting as molecules are further away from each other when they are liquid water, which is a scientifically incorrect idea when pertaining to water, but correct for most other substances.

Third, children also explore evaporation, boiling, and condensation, often considered sophisticated topics necessitating cognitive differentiations that young children may not be ready for and may not be able to construct. However, our goal is not mastery of these ideas. It is offering children opportunities to engage in looking at evidence and to begin to theorize about phenomena that they experience in their everyday lives (Metz, 1995, 1997). We have so far studied some dimensions of young children’s engagement with these ideas (Varelas & Pappas, 2006; Varelas, Pappas, & Rife, 2006; Varelas et al., 2008).

In the Food-Web drama activity in the Forest unit, children, taking on the roles of animals, plants, and non-living entities, find a place in a “web” of various entities connected by red strings. In their left hands, they hold the strings of the entities they eat/need for survival, and in their right hands, they hold the strings of the entities that eat/need them. In the Forest unit, children explore plants and animals living in a forest community—underground, on the ground, and above the ground—their characteristics, classes they belong to, and relationships among them, including food webs. For reasons similar to those in the Matter unit, we “push the envelope” by introducing young children into food webs, a topic that the National Science Education Standards recommend for middle school grades.

There were differences between the Molecule and Food-Web drama activities. The two activities drew on language, gesture, space, movement, and visual resources differently because the teachers and children were attempting to accomplish different goals. For instance, in the molecule drama, proximity and speed were important aspects of representation. In the food-web drama, the representations of individual status and direction of the relationship from each entity to another, such as the caterpillar eats the leaf and not the other way around, were important. Children also had different levels of experience with the concepts that they were enacting. In most classes, except Jennifer’s 3rd grade and Begoña’s 2nd grade, the Molecule drama was done before children had any prior discussion on how molecules behave at different states of matter. The Food-Web drama was done toward the end of a unit after children had discussed plant-animal interactions and plant and animal needs for survival in temperate forest ecosystems (Varelas, Pappas, Kokkino et al., 2008).

Data Sources and Analysis

Data for this study included fieldnotes, videotapes, and transcripts of the classroom discourse and actions during the drama activities. First, the videotapes were watched without sound. Watching the videotapes on mute and taking notes enabled us to pay close attention to the kinesthetic actions that children and teachers were involved in and performed as critical elements of drama performances. Then we watched the videotapes with sound and produced transcripts incorporating both words and actions as we referred to our
earlier notes (while watching without sound) and the corresponding classroom fieldnotes. Using an event matrix (Miles & Huberman, 1994), we coded events in each of the two drama activities (Matter and Forest) in each of the six classrooms along the three dimensions of a communicative activity, ideational, interpersonal, and textual. Table 1 shows excerpts of the event matrix. In the ideational column, we specified the scientific ideas addressed; in the interpersonal column, we noted how children interacted socially with each other and their teacher during the activity; and, in the textual column, we recorded spatial, temporal, and material features of the activity. Affective comments were interspersed in the various columns as seemed relevant.

As noted above, this study is part of a collaborative school-university action research project. One of the advantages of collaborative teacher research is that the teacher collaborators’ perspectives, views, hunches, and ways of understanding their classrooms become integral parts of the research analyses. Thus, the summaries we produced by compiling all the coded events from each classroom and each drama activity were further enhanced by our teacher collaborators’ recollections and reconstructions of their lessons, and how it felt to them doing the drama activities with their children.

Finally, we analyzed all the summaries (Coffey & Atkinson, 1996) looking for themes and patterns across classrooms and drama activities using an iterative constant comparative method (Glaser & Strauss, 1967). The Findings section is organized around three themes that emerged. Whereas we coded classroom events and, thus, analyzed our data along the metafunctions of communication (ideational, interpersonal, and textual), in the themes that emerged these metafunctions are integrated to form a whole as they are in any form of communication. Relevant excerpts from transcripts were used to substantiate and illustrate the themes (Bryman, 2001; Holliday, 2002; Seale, 1999). Transcription conventions for the discourse excerpts appear in the Appendix; all children’s names are pseudonyms.

Findings

Dialectic Relationship Between Ideas and Enactments

Children used their bodies as more than just an object or a symbol. They used their bodies to actively construct and transform for themselves what it meant to be a molecule in a liquid or a chipmunk in a food web. Both drama activities also offered children affordances for expressing and constructing scientific ideas in
conversation with their teacher and their peers about the phenomena and topics they were studying. As such, their conceptions of molecules or food webs were being constantly revised during the activity, changing how children dramatized their roles over multiple chances. Children’s ways with actions and words provided them opportunities to negotiate ambiguity and both re-enact and re-articulate understandings.

Language as a Mediator of Ideas and Actions. When Sharon Gill asked the “actors” in her 1st grade class (the group that was acting as molecules at that time) to show her what happened when they were water vapor, they considered important features of molecular behavior along with other children in the class who performed the role of “audience-directors.”

Excerpt 1

At the beginning of Excerpt 1, an actor was puzzled with how to act out a macroscopic property of gases, namely, that some gases are invisible. However, other students in the director-audience group considered two microscopic properties—the relative distance of molecules (units 7 and 12), and their speed (unit 10). At that point, these ideas did not evolve into articulated understandings about how molecules behave in the gaseous state; they were, nevertheless, tools students used to imagine what being a molecule in water vapor might be like. Thus, children used the drama activity to begin to theorize about the movement, relative distance, and speed of molecules. This excerpt also shows the reciprocal nature of meaning making in which students in the class were engaged. That is, they employed both kinds of tools, kinesthetic and language, to engage with ideas. As one group acted out molecule behavior, the students in the audience modified the group’s actions through verbal commands. Each group needed the other to enact the “ideal” behavior of molecules.

In Jennifer Hankes’ 3rd grade class, children “turned up the heat” in the Molecule drama by making a motion with their hands as if turning a knob and an (increasingly louder) swishing sound with their mouths, as they changed states of matter. When a group was acting out water in a liquid state, Jennifer posed a question to focus the children’s thinking and acting: “Pretend to turn up the heat even more. What’s going to start happening?” And children contributed:

Excerpt 2
Thus, in Excerpt 2, children linked the concept of heat (unit 1) with molecular behavior in the gaseous state (unit 2) and the scientific term for the water in that state (unit 6), as Ramona made a connection with the everyday experience of boiling water where bubbles (of water vapor) break off from the liquid water and “pop off” (unit 4). At another time, when another group was an ice cube and Jennifer asked, “If it gets warmer in here what’s going to happen?” (guiding her students to link important ideas such as temperature and molecular behavior), students made a swishing sound. As she prompted her students for more information by asking, “We’re gonna start to do what?” children offered “melt” and “get looser.” In this way, children related the macroscopic process (melting) with the microscopic process (molecular bonding becoming looser) when solids turn to liquids, as they connected the scientific term of the process with the actors’ actions (“get looser”).

In the Food-Web activity, again in Jennifer’s 3rd grade class, children considered themselves as particular entities and, as they had to decide how they would be connected with each other, they debated discussing ideas they have read about or were thinking through at that moment. The drama activity also became a resource for student questioning and sense-making.

Excerpt 3

In Excerpt 3, as children were deciding on how to create their food web, many animal characteristics were considered, such as turtles’ shells or owls’ beaks, informed, in this case, by read-aloud books read in the unit (for information books read in the Forest unit, see Varelas, Pappas, Kokkin et al., 2008). Deangelo, as he played a turtle, contended strongly that a fox could not eat him, and the teacher acknowledged his point, but also challenged it and encouraged further thinking on this. Latessa took up this opportunity and made an intertextual connection to a book the class had read (Look Out for Turtles! [Berger, 1992]) to argue otherwise (unit 7). And although the discussion at that moment was about animals eating a turtle, Yvonne brought up the idea that green plants are part of the food web (units 8–9 and 21–23), leading to Latessa’s question about her role (playing a seed) in a food web (unit 23).

Journal of Research in Science Teaching
In her 3rd grade class, Neveen Shamah also engaged her students in thinking about the scientific ideas and meanings represented by the Food-Web drama activity. One of her students, Sally, was the turtle, but Sally was not included in the dramatic enactment and was ignored by Neveen because the food chain that was constructed revolved around trees—and turtles did not “eat trees.” In Excerpt 4A, Neveen continued asking her students to expand the already formed food chains and web, and Sally continued trying to include herself in the action.

Excerpt 4A

In unit 1 of Excerpt 4A, Neveen asked what ate the grass. By using “the,” the definite article, to describe grass, Neveen foregrounded the person/actor playing the role of grass and not grass as a plant. However, the metaxic moment was retained, as the children continued to occupy real and dramatic worlds at the same time. Sally, still trying to participate offered “a termite” (unit 11) as an answer to what else might eat grass, knowing that her friend, and tablemate, Andres, was also still sitting in the audience on the periphery of the web. But Alita foregrounded the imaginary scientific world by asking Andres whether termites ate grass. Andres answered in the negative and did not rise to participate in the drama. He adhered to what he had learned about termites, that they ate wood. Neveen’s question in unit 14 also complexly evoked both the ontological/scientific world and the world of the students’ imagining. Even though the original actor playing the worm was absent that day, Sally, as the worm that day, was finally included in the food web. Andres, by unit 24, was still not a part of the food web. Enacting the imagined/scientific world, he realized that if he were not eating wood, then he would not be eating at all and would also be exposed to the sun, something to which termites were sensitive. By occupying both worlds, the children and Neveen were able to address characteristics of various forest entities and their relationships.

As already seen in Excerpt 3 when Latessa in Jennifer’s 3rd grade class referred to the turtle read-aloud, the drama activities also provided sources of intertextuality that can be seen as similar to metaxis. Juxtaposing various texts is like being in two worlds and attempting to make sense of ideas by making connections between the two texts/worlds. The drama activities encouraged intertextuality that in turn allowed children to
engage further with representing scientific concepts. As Neveen continued working with her students to construct a food web, she referred them to the information books they had been reading.

**Excerpt 4B**

25  Ms. Shamah: What are you? Groundhog! What does the/what does a groundhog eat?
26    Kira: (** ***).
27  Ms. Shamah: Okay. But we learned about other things that they eat. [To class.] What does the groundhog eat from the books we’ve read?
28    Sally: Look up there, man [referring to class animal charts].
29  Ms. Shamah: Nobody remembers? Didn’t you make a list? [To Kira.] What was on your list?
30    Kira: Vegetables and herbs and seeds.
31  Ms. Shamah: And seeds? Okay.
32  Yesenia: Oh, we got the seed.

In unit 27, Neveen referred to the information books of the unit that were read aloud to the children. This reminded Sally of the charts that the children had made on animals from each of the vertebrate classes. On these charts, the class had noted various aspects of the life of mammals, amphibians, reptiles, fish, and birds. These were: physical characteristics, what they eat, their enemies, their homes, their babies, and what was “cool” about them. By turning to these texts, Sally acknowledged their relevance and usefulness and used them to forward the enactment. Furthermore, in unit 29, Neveen hinted at a journal entry that children wrote before starting the Food-Web drama, namely, the journal entry where children listed what the entity that they would “play” in the drama eats/needs, and what it is eaten/needed by. This hint helped Kira (unit 30) contribute to the expansion of the food web.

**Serendipity of Ideas and Enactments.** Back in Sharon Gill’s 1st-grade class, Sharon also made sure that children linked scientific ideas to the Food-Web drama. At the beginning, she named the entities she wanted to be part of the web and asked the children representing those entities to come on up. However, she also asked children to say what one or another animal ate. Sharon let the children talk to figure out amongst themselves about who ate what. She later intervened.

**Excerpt 5**

1  Ms. Gill: . . .Okay. So we have a caterpillar here. We have dry leaves. Anyone eat these things?
2    C1: [Raises hand.]
3  Ms. Gill: If you do, come on.
4  C2: I eat
5  Ms. Gill: If you’re supposed to be up here, you need to come. Come on.
6  Cs: (** ***). [Several Cs approach web.]
7  Ms. Gill: Uh oh, (** ***). There you go. (** ***). Okay. Everybody freeze. Can anyone help Jasmine? She’s a butterfly, and she doesn’t know where to go. Tell her some place. Tell her/give her some place to go.
8    C: Flowers!
9  Cs: Flowers! Flowers!
10   C: Get over there.
11   C: Get over there.
12  Ms. Gill: Okay. Um. [Unclear to whom, probably Alam, who is a tadpole.] Okay, why are you holding on to the string?
13    C: It could eat
14  Ms. Gill: Unhuh. Excuse me!
15  Cs: [Become quiet.]
16  Ms. Gill: Why are you holding in there?
17    C: Me?
In Excerpt 5, Sharon and her children shared authority when deciding where different students would fit in the web. She asked the class where Jasmine, the butterfly, should go (unit 7). She let them figure out the food web in a way that seemed reasonable to them, but she also asked them “why” (unit 12), and she insisted on an answer (unit 18). As Alam, who was playing a tadpole, tried to find a place along a string in the food web, he and some other children considered what tadpoles eat, that underwater plants are different from ground plants (units 19 and 21), and finally that a tadpole is part of the frog family, the frog life cycle (units 32 and 35). These are science ideas that were initiated and debated by children because they were engaged in acting out the drama in a way that made sense to them and at the same time made sense to Sharon, their teacher. However, these ideas did not necessarily emerge in other classrooms. This is one of the limitations, but the beauty, too, of the process drama that does not have an \textit{a priori} script. Ideas and enactments emerge as the participants (children and teacher) think about them and act in ways that stimulate certain ideas and not others. That is why dramatizing should be used and considered as one of the various curriculum genres that need to be enacted to support teaching and learning of science.

In Excerpt 5, Sharon and her children shared authority when deciding where different students would fit in the web. She asked the class where Jasmine, the butterfly, should go (unit 7). She let them figure out the food web in a way that seemed reasonable to them, but she also asked them “why” (unit 12), and she insisted on an answer (unit 18). As Alam, who was playing a tadpole, tried to find a place along a string in the food web, he and some other children considered what tadpoles eat, that underwater plants are different from ground plants (units 19 and 21), and finally that a tadpole is part of the frog family, the frog life cycle (units 32 and 35). These are science ideas that were initiated and debated by children because they were engaged in acting out the drama in a way that made sense to them and at the same time made sense to Sharon, their teacher. However, these ideas did not necessarily emerge in other classrooms. This is one of the limitations, but the beauty, too, of the process drama that does not have an \textit{a priori} script. Ideas and enactments emerge as the participants (children and teacher) think about them and act in ways that stimulate certain ideas and not others. That is why dramatizing should be used and considered as one of the various curriculum genres that need to be enacted to support teaching and learning of science.

Although the drama activities did not have a script that the children were supposed to follow, they had guidelines that children acted out in their own ways. Thus, the dramas offered various unplanned and serendipitous opportunities for nurturing the children’s developing knowledge about the behavior of molecules. For instance, the students in Group 3 in Neveen Shamah’s 3rd grade class were covering some distance around the room as gas molecules, but were not moving fast. Neveen asked a question to challenge children’s actions.

\textit{Excerpt 6}

1 Ms. Shamah: Does gas move slowly?
2 Group 3: [Cs start to move faster. Luz bumps on a table.]
3 Ms. Shamah: Luz bumped into a table. Does that happen? Do gas molecules bump into each other?
4 Cs: Yeah.

Luz’s unexpected bumping on the table (unit 2) offered Neveen the chance to highlight for the class an important science idea, namely, that molecules bump into other matter and into each other, thereby expanding children’s understandings.

Moreover, mismatches in actors actual and ideal behavior afforded opportunities to talk about molecular behavior. In Sharon Gill’s 1st-grade class, on a day after the whole class had enacted the drama activity in front of each other, Sharon took small groups one at a time out into the hallway and told them to be either a solid, liquid, or gas. The rest of the children sat at their desks and were supposed to guess what state of

\textit{Journal of Research in Science Teaching}
matter the group was dramatizing. As groups tried to depict the state they were supposed to be, opportunities arose for the class to discuss and describe the behavior of molecules in liquids and gasses.

Excerpt 7

1 Ms. Gill: [Picks an all-boy group and goes out into the hallway with it.]
2 Actors: [3 boys come in the room bouncing up and down and about 1–2 feet apart.]
3 Audience: [shouting] Liquid! Liquid!
4 Ms. Gill: How many people say gas?
5 Audience: [No hands go up.]
6 Ms. Gill: How many people say liquid?
7 Audience: [All hands go up.]
8 Ms. Gill: What are you guys?
9 Actors: Gas!

... 
10 Ms. Gill: [Calls an all-girl group that disappears to the hallway.]
11 Actors: [4 girls come in 2–3 feet apart. The second girl does the breaststroke and blows up her cheeks.]
12 Actors: [Girls in group run around the room.]
13 Ms. Gill: Now, group. Boys and girls in the classroom, you were right, they came in like gas, but actually they were supposed to be liquid.
14 C in aud.: That’s what I thought they were.
15 Ms. Gill: Yeah, they don’t know the difference. What was wrong with that group?
16 C in aud.: They were too crazy.
17 C in aud.: Too riled up!
18 Ms. Gill: What were they doing that gas does?
19 Actors: [Still moving around the room.]
20 Ms. Gill: What does gas do?
21 C: Run fast.
22 Ms. Gill: And what does liquid do?
23 C: Slower.
24 C: Kind of closer together.
25 Ms. Gill: They’re closer together, aren’t they? Okay, girls, you girls need to go back to acting school.

In Excerpt 7, the interactivity of ideas and actions, of the real and imagined worlds, and of actors and audience all come to the fore. In Sharon’s earlier drama enactments the day before, the audience had acted as the “knowers” dialoguing with the actors about what to do and how to move. In contrast, in this present enactment of charades, the audience switches roles and becomes guessers. However, all students are allowed, ultimately, to decide what counts as a faithful representation. In units 2–9, the boys, thinking that they are representing gas molecules, bounce up and down and are far away from each other, but are interpreted by the audience behaving like liquid molecules. In lines 10–14, a second group is also judged by the audience to render liquids unfaithfully. The differences between what the actors were doing and what the audience thought they should be doing offered opportunities for children to talk about the behavior of molecules in different states. As Sharon engaged the children in thinking about the actions of the group and the “actions” of gas and liquid, the children were engaging with ideas related to molecules, such as comparing liquid and gas molecules’ relative speed (“slower,” unit 24) and closeness (“kind of closer together,” unit 25).

Differentiating Between Imagined (Scientific) and Real (Model) Worlds

As the children in the various classes were engaged in the drama activities, they had to juggle the physical affordances of the actual 3D settings they were in with ways of being and moving that were faithful to the scientific system and phenomenon they were representing. At times they had to differentiate between imagined and real worlds and the teachers played important roles in initiating and supporting such differentiations.

In four out of the six classrooms (the two 1st grade and the two 3rd grade classrooms), when children were pretending to be molecules in the Molecule drama and were told to melt, at least one student got closer to
the floor by bending the knees and squatting or falling all the way to the floor. In a 1st grade classroom, when this happened, the teacher, Sharon Gill, said to the class that instead of falling down, they had to “stretch” to show that they were melting. In Jennifer Hankes’ 3rd grade, when she told a group of children to melt, all four of them sank to the floor to which Jennifer responded, “We could melt like that, but instead we’re gonna loosen our bonds.” Melting down is a representation of the process in the ontological world. When a chunk of ice melts, it does not stand up any more, it flows downwards on the surface it is on. However, in the imaginary scientific world, melting means that bonds are loosened up among molecules, which, of course, explains the “flowing” property of liquids.

Continuing with Jennifer’s class, let us revisit Excerpt 2 in a more elaborated form as it appears below in Excerpt 8A.

Excerpt 8A.

1 Ms. Hankes: Now we’re a little bit looser. But we’re still staying in the glass, aren’t we? We’re in the glass and we’re still moving. All right. Pretend to turn up the heat even more. What’s going to start happening?
2 Cs: (***)
3 Ms. Hankes: Whoa, whoa. You know, can I have somebody raise their hand? I couldn’t hear. I heard so many good ideas. Michelle.
4 Michelle: Y’all gonna get hot.
5 Ms. Hankes: We’re gonna get hotter and when molecules get hot what do they start doing?
6 C1: Go faster!
7 Ms. Hankes: They start moving faster [as she (and students) begins to move arms and legs faster] and what’s gonna end up happening to them?
8 Cs: (***)
9 Deangelo: Disappear!
10 Ms. Hankes: What? Ramona?
11 Ramona: They gonna pop off and turn into water vapor.
12 Ms. Hankes: So if we’re starting to boil, what’s happening to us?
13 Jamilia: [Starts to jump.]
14 C2: [Makes a swishing sound.]
15 Ms. Hankes: We’re coming out of the glass and we’re becoming a what?
16 Cs: Water vapor!
17 Ms. Hankes: [She (and students) begins to leave the classroom. She walks with her arms outstretched.]
18 Cs (in group): [Walk randomly around the room, including back into the cup.]
19 Ms. Hankes: You’re a gas now. You’re out of the cup! You’re out of the cup.
20 Deangelo: Get out of the cup!

As Jennifer was scaffolding the dramatization of the various states of matter, and changes from one to another, Jamilia jumped up (unit 13) to turn into gas, which Ramona had described as “pop[ping] off and turn[ing] into water vapor” (unit 11). Jumping and “popping off” movements are consistent with a vertical orientation (in the direction of gravity) that, of course, the children are used to when being in the classroom, like walking, standing, sitting, and so forth, all characteristics of the ontological/real world in which they were dramatizing science. However, the cup with the ice cube outlined on the floor where the children’s dramatization was taking place, was oriented on a horizontal plane. These children’s movements reveal more attention to the macroscopic behaviors of substances. Ice melts downward; water vapor goes up. This was yet another example of metaxis that unfolded during these drama activities. In addition, many students (and teachers) in all of the classrooms represented water vapor by spreading their arms, as if they were flying, a modification to fit the constraints that kept them tethered to the floor. Spreading their arms was accompanied by the recognition that gas molecules “fly everywhere.” (In fact, one boy in Sharon’s 1st grade class also made noises like a motor as he “flew out of the cup” as water vapor.)

As Jennifer continued working with her children, yet another way of being in both the real ontological world and the imaginary scientific world emerged as children used typical everyday movements to represent scientific concepts.
Excerpt 8B.

21 Ms. Hankes: You’re a gas now. You’re flying around the room. You take the shape of the container you’re in. We could be over here. We could be over there. If we were small enough we could slide under the door. All right? Turn it back, cold.

22 Lawrence: [Slows down his movement.]
23 Chantrelle: [Wraps her arms around herself as if she is cold.]
24 Ms. Hankes: What’s going to happen to our water vapor? We’re not moving as fast anymore. [She slowly walks back to the masking-tape cup.]
25 Actors: [Follow Ms. Hankes.]
26 Ms. Hankes: [Reaches out to hold hands.]
27 C3: Turn into a cloud.

Chantrelle’s way of playing being cold (unit 23) comes from the ways we often behave when we are cold in real life. Eventually Jennifer succeeded in making Chantrelle (and other children) stop using that world as a resource for her acting as she holds hands with the other members of her group to play a liquid (or a “cloud” as a child said in unit 27) in the scientific way.

In a similar situation, Anne Barry needed to help her 1st graders differentiate between the “freezing” directive in the classroom as part of classroom routines (i.e., when she wanted to get students’ attention, Anne asked them to freeze by stopping what they were doing and not moving) and the “freezing” of molecules that the children were enacting. Later on they changed from liquid to gas as they evaporated.

Excerpt 9.


2 Ms. Barry: You’re turning from a liquid to a gas. All right. Where are you going as a gas? Come on.
3 Cs: [Begin to separate from each other and move about.]
4 Ms. Barry: You can’t go out the sides. You gotta go out the front//the top. Where are you going? You’re gas. Come on you’re a//evaporation. [Leave the masking-tape cup/glass and move about the room.]
5 Cs: [Leave the masking-tape cup/glass and move about the room.]
6 Ms. Barry: Good. Where can you//oh you don’t walk in the glass but you go out the top.

In units 4 and 6 of Excerpt 9, we see another instance of the tension between the two orientations, the vertical one that the children were used to as part of their everyday lives and the horizontal one in which the cup on the floor was outlined. Thus, the children first tried to escape from any place inside the cup as they perceived it as open and they could not “see” any sides (that would make it impossible for gas to pass through). However, Anne kept reminding and articulating for them that, in the imaginary scientific world they were in, evaporation only happens from the opening (top) of a cup, and thus they could only move out from that way.

Furthermore, over time, students’ dramatic enactments drew more and more on the rules of the drama genre itself, the imaginary scientific world that they were acting out, and not those that were dominant in other parts of schooling, the real world they were living in. For example, across all classrooms in the Molecule activity, students in the first groups were reluctant to run around the room when they were told to be gas molecules. In other activities in the classroom, students were explicitly told that they should only walk and not run in the classrooms. In the later dramatizations, participants had the benefit of watching, commenting on, and listening to remarks about previous groups, and were able to push the acceptable limits of their bodies’ movements in the spaces of the classroom. As more and more groups of children were actors in the activity, they began to run faster and cover more space.

On yet a different level, in Neveen Shamah’s 3rd grade class, children’s gendered lives were also obvious during the formation of the first group. Boys and girls giggled when they had to be with someone of the
opposite gender holding hands or being too close when they were representing a solid. In this case, their teacher admonished them, “Do we care that he’s a boy and she’s a girl? No. We are molecules. Do it for science!” Thus, children’s bodies had both physical/material and semiotic social dimensions (Cheville, 2006). That is, children were inscribed with the rules of the cultures and social institutions (Foucault, 1979; Luke, 1992) that they were a part of, and such rules were different from the rules of the scientific system they were enacting. The teacher had to help them differentiate between these two rule systems. This is another challenge that dramatizing presents, similar to other forms of modeling. Differentiation is needed between the two systems/worlds involved in any modeling situation if students are to develop canonical scientific knowledge and understandings.

The Humanness of Dramatic Modeling

One of the distinctive characteristics of dramatizing as a form of modeling is that the people themselves are involved in the modeling, populating the real world in which they perform and, thus, infusing the imagined, in our case scientific world, with human elements, such as feelings, attitudes, actions, and behaviors towards each other and towards the entities they pretend to be. In the Food-Web drama, children negotiated interpersonal relationships as they pondered and discussed scientific relationships between forest entities to explore interdependence. In some ways, as the children became animals, plants, and inanimate entities, they did not forget who they were—children who wanted higher social positioning, or more power, than their peers. Their places in the food chains and webs they were enacting could not always be divorced from such feelings and opinions.

In Neveen Shamah’s 3rd grade class, Andres was made fun of as a “t-t-t-termite.” As the web was beginning to take shape, he said: “Damn, this sucks, I’m gonna be all the way at the end.” Sally also teased him about this, and his group-table members (especially Sally) had teased him the day before when he was assigned to be termite and the class was figuring out who ate whom. In Excerpt 10A, Andres is already a part of the food web, and Neveen is leading the class through imagining what it would be like to disrupt the food web by killing off an entity in the forest community.

Excerpt 10A.

1 C: Nothing eats me.
2 Ms. Shamah: Nothing eats you?
3 Kira: I didn’t eat any animals.
4 C: The owls.
5 Sally: Termite eats you.
6 Ms. Shamah: Oh termites eat you. Where’s the termite?
7 Sally: Right there. Hi, t-t-t-termite.
8 Dante: Hi, t-t-t-termite.
9 Ms. Shamah: The only thing you eat is wood, termite. Right? So what are you holding on to?
10 Andres: Uh the ant and the frog.
11 Ms. Shamah: Uh the ant and the frog. And the termite only eats what?
12 Cs: Wood.
13 Ms. Shamah: You don’t have anything to eat. Here you go. Here, hold it. [Tries to toss end of string to termite Andres.] Here you go. Give that to him. Okay. Are you happy now? [To class.] So let’s say this. The termites/we’ll do this really fast. The termite only eats what?
14 Cs: Wood. [Puts arms around the tree C’s shoulders.] You’re dead tree. You’re gonna die, termite. You’re gonna die.
15 Ms. Shamah: You’re gonna die, termite. You’re gonna die. (*** ***).
16 Sally: They’re gonna die because that’s their only food.
17 Cs: Wood. [Puts arms around the tree C’s shoulders.] You’re dead tree. Bye, bye.
18 Ms. Shamah: Bye, bye. You’re dead. Okay. What do you think is gonna happen eventually to all the termites?
19 Cs: (*** ***).
20 Ms. Shamah: Sally. Since you’re raising your hand and everyone else is yelling. Where’d my tree go? You’re supposed to be dead. I’m sorry, Sally. Go ahead.
21 Sally: They’re gonna die. They’re gonna end up dying because that’s their only food.
Sally continued to react to the forest entities, relating feelings (in a humorous way) to her sense of being better than others. As we saw earlier in Excerpt 5A, Sally was playing both a turtle and a worm. At a certain point (not included in the above excerpt), she said to another child: “Ha, ha. I eat you either way [as turtle or worm].” Later on, in Excerpt 10B, as Neveen hinted to the conversation that the class had about worms not having a particular sex but being both males and females, Sally did not like the name “Herman” (unit 33) that the teacher called her, which was the name of the worm in the website (http://www.urbanext.uiuc.edu/worms/) that the class had explored. While discussing that website, the children had associated the name “Herman” with being both female (“her”) and male (“man”). Sally rejected being both male and female, as it seemed to disrupt her status as a girl.

Excerpt 10B.

As the conversation continued in Neveen’s class, this time other classmates teased Sally as they repeated the “Herman” name that Sally did not like (units 33–34). Moreover, as Neveen engaged the children in thinking about what would happen to forest entities when others disappear, Sally realized that when the beaver was not connected to the tree, the beaver was still connected to her so it would survive (unit 41). Although the beaver would eat her, she was excited she could save the beaver.

In Excerpt 10C, Dante (playing a prairie dog) found himself with a new, higher status in the food chain when the hawk was gone. An appreciation of the intricate relationships that determine survival in the forest community is expressed as he empathizes with the prairie dog’s survival.

Excerpt 10C.

Similarly in Jennifer Hankes’ 3rd grade class, Joe and Jamilia’s bantering continued when they were dramatizing the food web. While Jennifer was handing out red string, various students were discussing who
would eat whom. Joe, who was playing a raccoon, kept talking in a teasing tone about eating Jamilia who was a snake, and Jamilia argued back that she ate him.

**Excerpt 11A.**

2. Jamilia: Unhuh. I eat you [to Joe]. I eat Taliesha [who was a frog].

Later on, as Jennifer worked with her students to enact more branches of the food web, dramatic roles and scientific entities and relationships were mixed again. Jennifer called the robin up and anybody who ate it.

**Excerpt 11B.**

4. Jamilia: Me?
5. Tasha: What about an owl?
6. Cs: [The earthworm and termite came up.]
7. C1: Amber [water].
8. C2: What about plants?
10. Ms. Hankes: Mary [termite], what do you need to eat?
11. Mary: Yvonne [tree].
12. Ms. Hankes: What would happen if the robin died? Raise your hand if you would have nothing to eat as of right now.
14. Ms. Hankes: Now imagine if Yvonne, trees, didn’t exist. Who would not be able to survive?
15. C1: Termites.
19. Ms. Hankes: Okay, you’re right. This is a good point here. She makes the trees but doesn’t/in order for Tasha to exist, doesn’t there also need to be a tree to make the new seeds?
20. Amber: And the water.
21. Ms. Hankes: And the water. So if water didn’t exist would any of us be here?
22. Cs: No.
23. Amber: Ms. Hankes, everybody got me [water].

Children became the forest entities in some ways, but played out their real world identities in other ways. In Excerpt 11B children used each other’s names to refer to what forest entities needed to survive. These hypothetical entities children pretended to be had the children’s own names. The children were themselves, but at the same time they were not, they were forest entities—a state of metaxis. Some children were needed more than others in this pretend setting where they were plants, animals, water, sunlight, but at the same time, they were Jamilia, Joe, Yvonne, Deangelo, Tasha, and Taliesha.

**Discussion**

In this study we explored meanings that children made in dramatic enactments of molecular behavior in different states of matter and of food webs in a forest community. These meanings were not generated in individual children’s minds. They were collaboratively and interactionally constructed among the members of these classrooms—among the children themselves and between the teacher and children. The study reveals the overlap, but also the uniqueness of, these meanings and the ways of symbolizing them. In this way, the study sheds light on children’s multimodal ways of dramatizing science ideas as a means of negotiating ambiguity of meaning and developing and communicating understanding.

All human action is mediated (Wertsch, del Rio, & Alvarez, 1995). That is, individuals do not act immediately on the world, but with tools that already exist in social and material realms (Vygotsky, 1934/1987). These tools range from abstract structures of social organization such as “speech genres” (Bakhtin, 1986; Wertsch, 1991) to the “huddles” of children’s bodies as molecules in a solid state and their webs of red
strings that they held as forest entities. In the drama activities we explored in this study, children’s whole bodies became central, explicit tools used to accomplish the goal of representing the imaginary scientific world. Furthermore, children’s bodies operated on multiple mediated levels in these drama activities: as material objects that moved through space, as social objects that negotiated classroom relationships and rules, and as metaphorical objects that stood in for water molecules in the various states of matter or for entities in a food web. Children simultaneously negotiated meanings across all of these levels, and in doing so, acted out the drama as they thought and talked science.

Moreover, in the drama activities, scientific ideas became aesthetic objects, entities filled with thought and feeling. According to Dewey (1934), aesthetic experience involves “interpenetration of self and the world of objects and events” (p. 34). By dramatizing science, children’s bodies and scientific concepts of molecules and forest entities became intertwined, showing how scientific ideas share features with works of art as aesthetic entities. Molecular behavior in various states of matter and interactions among animals, plants, and inanimate entities in a forest community turned out to have unity, intensity, harmony, rhythm, balance, and order—elements of beauty in aesthetics (Flannery, 1991).

At times, tacit knowledge led children to act in a particular way. That is, their everyday, material, place-based, real-world experiences have helped them develop knowledge that they first used to think about, encounter, and construct the imaginary world of scientific entities that the drama activities immersed them in. One challenge associated with dramatic representations is that there is not always an “exact fit” (Duit, 1991, p. 666) between the representation and the scientific idea(s). In these cases, their teachers intervened and showed them what to do, differentiating at times and uniting at other times what the children were doing and the scientific entities and behaviors that they were representing. In this way, children were helped to differentiate the model world and the real world, and at the same time build bridges between the two—an important factor in the success of modeling as an instructional tool (Coll et al., 2005; Duit, 1991; Gilbert, 1993). However, we do not know whether individual children constructed this differentiation. What we know is that as more and more groups enacted the dramas, they collectively represented more and more accurately the scientific world. For example, whereas earlier groups in various classes “melted” by falling down, later groups “melted” by loosening hand/arm bonding, spreading, and moving faster.

Givry and Roth (2006), exploring the interplay among talking, gesturing, and using contextual structures, claim that conceptual change may come in three different forms: “(a) evolution in the use of modalities... (b) evolution into the same modality... and (c) evolution of the link between different modalities” (p. 1105). In dramatizing, as different children over time engaged in both the real world and the world of science that they were acting out, children evolved in the bodily-kinesthetic modality they were using to represent scientific constructs. Furthermore, language played an important role in being in both worlds and in coordinating them. Teachers asked questions that fell in a range of categories that Chin (2007) specified as approaches that stimulate productive thinking; for example, asking students to provide more information (pumping), asking questions based on a statement or question by a student (reflective toss), asking questions as forms of feedback to a child’s contribution (constructive challenge), asking questions that guide students to develop links among ideas (association of key words and phrases), asking questions that stimulate multimodal thinking, and asking questions that encourage students to focus more and zoom into their thinking.

However, it is also important to keep in mind that semiotic systems other than language cannot be clearly translated in words. Givry and Roth (2006) have argued that gestures “are topological (i.e., have spatial characteristics) and imagistic in nature and therefore inherently different from words, which are typological, naming objects and concepts... [Although] gestures cannot be interpreted outside the speech situation in which they occur... [they] cannot be simply rendered in verbal terms” (p. 1095). In similar ways, the dramatic enactments we studied were topological and the physical dimensions of the children’s actions could not all be captured and represented in words.

Although there were guidelines for both drama activities, the enactments of these activities were different in different classrooms. There are no scripts for improvisational plays; the actors make these plays while interacting with the audience, creating characters and events that create the plays. In similar ways, the children created the drama activities, along with their teachers. They negotiated various representations as they tried to get inside the worlds they tried to understand and learn. They were the entities in the imagined
worlds; in fact, they became the entities as time was going by and as they kept “playing science.” In this way, the children populated these drama activities with their intentions and their meanings (Bakhtin, 1981). Maybe this is one of the reasons why dramatizing was enabling for the children’s learning. We know from the various studies on modeling and its use in science teaching and learning that students’ own modeling is important to their understanding—“enabling students to construct and critique their own models effectively supports conceptual development outcomes (Abell & Roth, 1995)” (Coll et al., 2005, p. 187), albeit insufficient as “many of students’ personal analogies and explanations...[could be] unsuccessful at leading them to scientifically accepted ideas about the concepts (Yerrick, Doster, Nugent, Parke, & Crawley, 2003, p. 459). The children in our study made the drama activities their own but had not originally conceived them.

Students’ representations in space provided referents for the science talking and thinking. Their roles, as actors, guessers, directors, and viewers, allowed them to engage with science content from multiple perspectives. Although all the children in a class enacted the same script, each one acted out her or his role differently and made it her or his role. That is exactly the power of performing arts: each actor becomes the role in his or her own way, capturing the uniqueness of the ideas to be communicated to the audience. However, this is a challenge at the same time, too, as it leads to the serendipity of the scientific ideas that are explored, discussed, and developed as part of the drama activities.

In these drama activities, the children had no “formal” stage. Their stage was their classroom, the place in which they lived, breathed, argued, teased, struggled, got bored, felt good, and where they were with classmates and friends every day. Because that was their classroom, they knew of certain norms and rules governing that space which precluded them from some of the actions they might do in the imaginary world of molecules or forest entities.

The drama activities provided opportunities for children to work in both dimensions of scientific activity—sign-referent and sign–sign. They linked scientific constructs to referents (namely, themselves who played molecules or forest entities) and they negotiated being both in the real world and time/space of the classroom and in the imaginary microscopic world of matter or the world of a forest ecosystem. They also linked scientific constructs with each other. They considered similarities and differences among solids, liquids, and gases; they associated transfer of heat with changes in states of matter; they discussed animal characteristics vis-à-vis the place of an entity in a food web; they considered the importance of certain entities for other entities in the forest. In these ways, the chronotopes that made up these drama activities were sites of thinking, reasoning, and exchanging of ideas, but also intermingling of social relations and emotions—showing empathy for animals eaten by others and excitement being molecules in a gaseous state running around the classroom and bumping on classroom furniture and their peers. The significance of space and time in both worlds that a drama involves—the real world where the children lived and the pretend world that they were enacting during the drama—became apparent.

In some ways, the dramatizing offered an opportunity to create hybrid science learning spaces that Barton and Tan (2009) called for. In these drama activities, the physical space of the classroom where the children spent many hours of their days was transformed to a space where they enacted scientific ideas. This space was familiar to them and, thus, invited them to be a part of it in a different way so they could explore science. Albeit the challenges that the classroom space, which was governed by different rules, raised for engaging with scientific ideas in canonical ways, the acting out of science in this space also transformed the classroom into a more fun place to be.

The meaning making that unfolded during the drama activities was multimodal. As the children moved, gestured, positioned themselves in space, and talked, they shared meanings—meanings that they constructed with their peers and their teachers as they enacted their roles. They negotiated ambiguity and re-articulated understandings, thus marking this embodied meaning making as a powerful way of their engagement with science. And it is worth remembering that these were not children in “privileged” schools and classrooms; on the contrary, they were mostly Latino/a (several of whom were English Language Learners) and African American children in high poverty urban schools, often unfairly and inaccurately characterized as having deficits in academic performance, in engagement, and in knowledge of various subject areas, including science. Deficit perspectives are particularly dangerous as they may “lower the quality of education for children from low-income households... The kinds of conversations available to them are diminished, the scope of the curriculum contracts, the modalities in which they are asked to represent their learning.

Journal of Research in Science Teaching
are constricted’’ (Bomer, Dworin, May, & Semingson, 2009). Thus, we offer with this study yet another hopeful piece of news about various children’s learning and engagement in science in urban school classrooms where children were seen as capable, competent, and knowledgeable, and their teachers offered them opportunities to use semiotic systems that remain understudied in the domain of science education research.

Most students see science as rational, cold, unexciting, and lacking any emotional content. Drama, though, is totally different. Dramatic enactments contribute to infusing science with emotions, excitement, fun, interaction, and shorten the distance between object of study and subject, providing a more holistic experiential approach to learning science. Such forms of engagement with ideas, topics, and fields of study may be more empowering to children, especially the ones who are members of particular cultural and gender groups, such as African Americans and women (Nobles, 1980; Rosser, 1990), groups that have been usually underrepresented in sciences and whose science education experiences have been fraught with challenges. In the drama activities we studied, the students became “insiders” of scientific phenomena and ideas, participating with their peers, and associating science with feelings of membership in collective activity. Despite short-lived, these “interactional rituals” (Olitsky, 2007) were characterized by the mutual focus that students had during them on particular “big” science ideas, like the micro-level characteristics of different states of matter and the ways in which animals and plants are connected in a particular environment. Although the aim of this study was not the exploration of individual engagement in and learning from the drama activities, we hope that further studies we are currently finalizing on focal children (drawing from various sources of data, i.e., classroom discourse, classroom artifacts—concept maps and murals—individual journals, children’s own composed books, and individual pre and post interviews) will allow us to further explore possible connections between membership in particular social groups and learning (broadly defined) in the context of multimodal activities, including drama.

Moreover, dramatizing, as a particular form of modeling, offers an opportunity to expand science education beyond dualisms—thinking and feeling, reason and emotion, mind and body, objectivity and subjectivity, masculine and feminine—dualisms that Brickhouse (2001) problematizes as she synthesizes her own and other feminist scholars’ research. Although uncovering how the domination of one of the two ends of these dualisms has shaped science and science education over time is an important contribution of feminist scholarship, continuing to think along these divisions limits people’s learning which is antithetical to feminist pedagogy. To support science learning for all, we need to understand how the two ends are embedded into each other and to appreciate their interplay, along with designing curriculum and instruction that nurtures such interplay. With this study, we identified ways in which one example of such activity, namely, dramatic enactments of science phenomena and concepts, engaged young children with each other, with science ideas, and with their social worlds.

The study is part of a larger project that was funded by a 4-year (2004–2008) US National Science Foundation (NSF) Research On Learning and Education (ROLE) grant (REC-0411593) to M. Varelas and C. C. Pappas as Principal Investigators. The data presented, statements made, and views expressed in this article are solely the responsibilities of the authors and do not necessarily reflect the views of the National Science Foundation. A version of this paper was presented at the annual conference of the National Association for Research in Science Teaching, New Orleans, LA, April 15–18, 2007.

References


Journal of Research in Science Teaching


Appendix

Conventions of Transcription for Classroom Discourse Excerpts

Speakers: Ms. [last name] is the classroom teacher. C, C1, C2, and so forth are noted for individual children. C is used if a child’s voice cannot be identified; Cn is used to identify particular children (but not by name) in particular section of the transcript (so that C1 or C2, etc., is not necessarily the same child throughout the whole transcript). Cs represents many children speaking simultaneously.

// Repetitions or false starts or abandoned language replaced by new language structures.

~ ~ Longer pause within unit.

Breaking off of a speaker’s turn due to the next speaker’s turn.

== A speaker’s pause at the end of uncompleted utterance, seemingly to encourage another speaker to talk.

< > Uncertain words.

(***) One word that is inaudible or impossible to transcribe.

(****) Longer stretches of language that are inaudible or impossible to transcribe.

Underscore: Emphasis.

# # Overlapping language spoken by two or more speakers at a time.

[ ] Identifies what is being referred to or gestured and other nonverbal contextual information.

... Part of a transcript has been omitted.