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"Everyday" and "Scientific": Rethinking Dichotomies in Modes of Thinking in Science Learning

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When we use the term "everyday" as a qualifier of our experience (as in "everyday experience"), we usually intend to convey an idea of our experience as concrete, familiar, commonplace, informal. Use of this term often implies a contrast with another form of experience characterized as scientific, precise, complex, formal. This trade in mutually exclusive contrasts for modes of thinking or kinds of meaning is a distinctive and long-standing tradition in Western thinking (Hymes, 1996; Goody, 1977; Lave, 1988; Leacock, 1972). It is one that has reverberated across many domains of inquiry and has assumed a similar, binary form: scientific versus everyday; abstract versus concrete; complex versus simple; analytic versus intuitive; decontextualized versus contextualized; advanced versus primitive; domesticated versus savage; theoretical versus practical; examined versus unexamined. Evaluation is built

into these dichotomies, that is, in how we use them to organize experience. The left-hand term of each pair is the more highly valued, reflecting a cognitive ideal involving *more* information, complexity, precision, analysis, and generality (Hymes, 1996; Lave, 1988; Leacock, 1972). Although these categories may be useful to us as we try to orient ourselves amid the disorder and uncertainty of life, Goody (1977) reminds us that this division into contrasting modes of thought is the product of "a folk-taxonomy by which we bring order and understanding into a complex universe. But the order is illusory, the meaning superficial" (p. 36).

Not surprisingly, the field of science education research has not been immune from this tradition of thought. Indeed, the whole question of the value or function of "everyday experience" in learning science—to take but one example, how laypersons experience the world and how the discipline of physics conceptualizes the world—has been a focus of continuing debate. Roughly speaking, the field divides itself into two camps: those for whom the sciences represent worlds largely *discontinuous* with ordinary, everyday experience, and those for whom the relationship between scientific understanding and everyday experience is fundamentally *continuous*.

The discontinuity tradition is represented in much of the work on student misconceptions (McCloskey, Caramazza, & Green, 1980; McDermott, Rosenquist, & van Zee, 1987; Viennot, 1979) and studies of instructional congruence (O. Lee & Fradd, 1996; O. Lee, Fradd, & Sutman, 1995). This tradition locates one major source of discontinuity in students' encounters with the physical and social world of everyday experience and interaction. It holds that students' everyday ideas are often wrong, strongly held, difficult to change, and interfere with learning. From a discontinuity point of view, the goal of education is to replace, repair, or fix students' wrong ideas and ways of knowing with correct ideas through a variety of instructional means.

An argument against the claims of misconceptionists and others who view "everyday experience" as a source of trouble was mounted in a paper by Smith, diSessa, and Roschelle (1993; see also diSessa, 1993; diSessa, Hammer, Sherin, & Kolpakowski, 1991; Minstrell, 1989). The core of their argument is that the framing assumptions of misconceptions research, which stress discontinuity between students and experts (e.g., scientists and mathematicians), conflict with the basic premise of constructivism, namely, that students build more advanced understandings from prior understandings. Building on diSessa's "knowledge-in-pieces" framework, Smith et al. (1993) offered an alternative view that takes up students' prior knowledge and experience as resources in developing mature understanding in physics. In support of this,

they identified important dimensions of continuity between students' ideas and those of experts where misconceptions research has identified discontinuities.

Our intention here is not to do an exhaustive review or analysis of this debate, only to point to some of the implications of each tradition with regard to matters of learning and teaching. These two traditions proceed according to quite different assumptions. The main point of contention is whether students' ways of conceptualizing, representing, and evaluating their lived experience should be viewed and treated as errors that impede learning or as generative resources in learning new ideas and traditions of inquiry. Our particular concern is with the implications of these two views with respect to children who are not experiencing academic success, typically children from low-income, historically underserved communities.

In the discontinuity view, children from historically underserved communities may appear especially disadvantaged because their "everyday" experiences and ways of knowing/talking/valuing are viewed as being the furthest from those traditionally valued in models of Western science or in national standards. Studies of instructional congruence (Lee & Fradd, 1996; Lee, Fradd, & Sutman, 1995), for example, focus on what the authors define as "incompatibility" between habits of mind as well as language and other interactional practices (e.g., deference to authority) they identify as characteristic of students from certain language-minority groups (e.g., Haitian-Creole and Spanish-speaking communities) and those valued in national science standards. They suggest that these putative habits of mind and interactional practices can impede students' learning in science. On this view, then, much of what these children bring in the way of culturally-based linguistic, intellectual, and experiential resources is not likely to be recognized or tapped as an intellectual resource in science learning and teaching.[1]

[1]We contrast the idea of cultural resources being deeply related intellectually to disciplinary content and practice with what we consider to be a shallow interpretation. The latter can be seen in instructional moves that introduce everyday experiences such as cooking rice and beans as a familiar context in a discussion of phase transitions, or that make note of the use of the Celsius scale in students' native countries in a discussion of temperature measurement scales. There is nothing wrong with these moves in and of themselves. But, often, they are not connected in any deep way with the core conceptual content or thinking practices of the domain. They thus come to represent the totality of what is seen as culturally grounded, to the exclusion of sense-making practices and understandings that in fact resonate deeply with those of scientific disciplines. They, in short, reduce culture to a referential function rather than seeing it dynamically as lived human experience within and across varied communities of practice (Gonzalez, 1999; Ingold, 1994; C. Lee, 2002; Moll, 2000; Rogoff, 2003), that is, as the acquisition throughout the life course of varied repertoires of cultural knowledge and performance capacities (Erickson, 2002).

Research in the continuity tradition takes a different view. Studies in this tradition have documented the various ways in which the experiences, ideas, and ways of talking and knowing of children from groups historically placed at risk are productively related to those characteristic of scientific communities (Ballenger, 1997, 2000; Conant, Rosebery, Warren, & Hudicourt-Barnes, 2001; Gee & Clinton, 2000; Hudicourt-Barnes, 2003; Michaels & Sohmer, 2000; Rosebery & Warren, 1999; Rosebery, Warren, Ballenger, & Ogonowski, in press; Warren, Ogonowski, & Pothier, 2000; Warren, Pothier, Rosebery & Ogonowski, 2003; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001; Warren & Rosebery, 1996). In each of these cases, children's inventive use of narrative, animated modes of argumentation, dynamic ways of imagining themselves into physical phenomena, among other sense-making resources, have repeatedly challenged teachers and researchers to examine their own, often limited and limiting, assumptions about what constitutes productive reasoning and deep understanding in the sciences. Thus, unlike the discontinuity tradition, this way of approaching learning and teaching challenges teachers and researchers alike to assume that children are always connecting in some important way to the discipline and to learn to see these connections in the unfolding life of the classroom, no matter how far what children say and do may initially appear from the teachers' or researchers' expectations and understandings.

We are, without question, sympathetic to the continuity side of the argument (see, for example, Warren et al., 2001), which as pursued by diSessa and colleagues (1993; diSessa et al., 1991; Smith et al., 1993) is concerned fundamentally with "uncovering children's competence" and exploring ways in which such competence can be supported to promote development of robust understanding of the physical world. This perspective emphasizes both the heterogeneity and generativity in what children know and know how to do in relation to scientific ideas and practices of representation. It views scientific knowledge as growing out of experience, as a refinement, not a replacement, of experience. In our view, the idea of "uncovering children's competence" is central to the goal of creating classroom communities in which all children learn deeply and from each other (Brookline Teacher Research Seminar, 2004; C. Lee, 1993, 2000; Warren et al., 2001). It entails openness to the many and varied sense-making resources that children bring from their lives outside of school and ongoing analysis of the generative ways in which these intersect with disciplinary ideas and meaning-making practices.

Within a continuity perspective, children's everyday experience is cultivated as an intellectually rich substrate for learning and development. In this

chapter we are interested in understanding the relationship between children's experience in the physical world and newly encountered scientific ideas, specifically, how children's "everyday experience" functions in relation to core disciplinary ideas and meaning-making practices in Newtonian physics. The study presented in this chapter explores how young children—first and second graders—used their "everyday experience" of downhill motion in understanding the behavior of toy cars and Newtonian ideas of force and motion. What kind of thing are these "everyday experiences"? How do they function as representations of emergent meaning in the children's inquiries? We use the term representation cautiously here. Our intention is not to suggest that children's accounts of their experience are mere redescriptions of a corresponding lived, past experience. Rather, we wish to suggest that their representations of their experiences running or riding bicycles down hills actually bring to life what did not fully exist before. In this sense, children's accounts of their everyday experience are not acts of replication or recall but acts of creative analysis, in which familiar events and objects are recast, ordinary meanings are subverted, and new possibilities for seeing and understanding are opened up (Rosebery et al., in press).

To begin, we present some background on the context of the study, then an analysis of two classroom episodes, followed by a discussion of the implications of this study for ways of thinking about the relationship of everyday experience and scientific ideas in children's learning in science.

THE STUDY

Background

The study took place in a combined first- and second-grade classroom in which students from diverse socioeconomic, ethnic, and language backgrounds investigated motion down an incline. The children's inquiry was part of a larger investigation of Newtonian ideas designed by their teacher, Suzanne Pothier, and the other authors who are members of the Chèche Konnen Center. The investigation as a whole was motivated by Ms. Pothier's own experience as a member of the Chèche Konnen teacher research seminar. In the seminar, she, other teachers, and Chèche Konnen staff investigated Newton's Laws as learners (see Warren & Ogonowski, 1998; Warren, Ogonowski, & Pothier, 2000). In parallel, we analyzed the talk and activity of children who initially puzzled us, either because they said something that was incomprehensible

to us or approached the topic from an unexpected place (Ballenger, 1999; Ballenger & Rosebery, 2003; Brookline Teacher Research Seminar, 2004; Gallas, 1994). Ms. Pothier was especially committed to learning to see the intellectual strengths and traditions of all her students, in particular those from lives distant from her own, and how these connected with scientific traditions of meaning-making. With this commitment in mind, she set out to explore what her first and second graders might be able to understand about accelerated motion and gravity, phenomena typically thought to be beyond the grasp of young children, and how they might approach making sense of these ideas.

Reviewing the district's approved curriculum unit (Education Development Center, 1997), Ms. Pothier decided to refocus it with an emphasis on ideas of motion and force. She organized the children's investigation around visible (e.g., pushes and pulls) and invisible forces (e.g., gravity). The children began in January by exploring pushes and pulls that they could observe or feel directly, for example, experimenting with ways to get a toy car moving from rest, and pulling first one, then two, then three boxes of copier paper. During their initial exploration of toy cars, one boy noticed that at times the car seemed to "move by itself," as when it rolled down his arm. This kind of motion, "moving by itself," became the subject of intense investigation over many months. The children experimented with toy cars on ramps, slid down a giant slide in the playground outside school, drew representations of changes in speed they perceived in a toy car as it rolled down a short ramp, constructed stories and cartoons of the car's trip down the ramp as well as their own trip down a giant slide, and in the waning days of the school year explored gravity as a possible cause of the changes in speed that they and toy cars experience as they each move down an incline.

About two months into the investigation, Ms. Pothier introduced the children to Sir Isaac Newton and some of his ideas about motion. Drawing from his First and Second Laws, she presented a formulation that expressed what is arguably the core principle of the Second Law in a nonmathematized form:

> Isaac Newton looked for:
>
> ➢ A change in the speed of an object
> ➢ A change in the direction the object is moving
>
> If Newton saw one or both of these changes, he said there has to be something forcing that to happen.

The class discussed how this idea related to their experiences working with visible forces. They then engaged in several months of activity investigating accelerated motion due to gravity. Ms. Pothier's goals for her students' learning were twofold: (1) that they come to see that an object moving down an incline is always increasing its speed, and (2) that they understand that gravity is the force that causes this continuous change in speed. Our focus in this chapter is on classes related to the first goal.

Ms. Pothier's intention was to put Newton's perspective on the kind of motion they would be investigating out on the table as a perspective to think with, probe, interrogate. This move derived from her own experience in the Chèche Konnen seminar, where Newtonian ideas were taken up in just this way, as an object of inquiry rather than as laws to be unquestioningly applied in solving problems (Rosebery et al., in press; Warren & Ogonowski, 2001) or as universal principles to be discovered. This investigation was also an experiment of sorts, insofar as Ms. Pothier was interested in seeing how her first and second graders would take up Newton's ideas about motion in light of their own lived experience.

We next present an analysis of two episodes from the class's investigation. The focal episodes are drawn from two consecutive classes beginning with the first time the children worked at exploring Newtonian ideas and motion due to gravity by observing changes in the speed of a toy car as it rolled down a short ramp. We focus on the talk and activity of three children—Letisha and Stacey in the first episode and Elton in the second. In both of these episodes, the children invoke aspects of "everyday experience" as they explore the toy car's motion. To show the kind of understandings the children developed over the course of their investigation, we then summarize later classes in the study, during which the children experienced this type of motion numerous times and in numerous contexts, both as observers and participants.

Letisha and Stacey

On the first day of interest, Ms. Pothier asked the children to work in pairs to observe a toy Hot Wheels™ car as it moved down a short (approximately 2-foot) ramp set at a predetermined steepness. Their instructions were to do four runs of the car down the ramp, note any changes in speed they observed, and then create a story of the car's trip, which they would later share with the whole class.

As the children observed the toy car's very brief trip, they noticed various aspects of its motion, often indexing changes in its speed to particular places

on the ramp. Some noted that the car "started off slow" at the top and then got fast; a few pointed to specific places on the ramp where the car went the "fastest," including, but not always, the end. Many identified a particular place along the ramp where the car "got faster," although the actual place varied from one pair of children to another as well as across runs of a given car; some children used Post-it notes to label the spot on the ramp where they thought this change occurred in a given run. Thus the children seemed to notice discrete moments of change from one speed "state" to another (i.e., from relatively slow to faster), as if there were *a* change in speed to be observed or a series of discrete changes (i.e., it got faster here and here)—a perfectly sensible perception given the task ("look for changes in speed"), the brief duration (approximately 2 seconds) of the car's run, and the inherent difficulty of directly observing a continuously changing quantity.

Even at this early point in the investigation, however, some students sensed that the car's speed might be changing more continuously or, at least, at multiple points during its descent. And some went beyond the given task to explore, in a way influenced by the circulation of Newtonian ideas, what might be "forcing" any observed changes in speed. Both of these ways of seeing motion on the ramp were present in the work of Letisha and Stacey, on whom we first focus.

Immediately after an initial run of the car, Stacey noticed that the car "went slow" near the top, "then it started going down and faster." At the same time, she perceived the car "going faster . . . up to about here," as she ran her finger from the start of the ramp to its midpoint. She summarized her observations as follows:

1. *Stacey:* So I saw this change in speed. They all—*[the car rolls down the ramp]* like that one got fast about here *[1/3 of the way down]* and some got fast about here *[1/4 of the way down]* and one got fast here *[2/3 of the way down]*.

Stacey saw the car's motion in various ways. She described it gaining speed as it went down ("then it started going down and faster"). In her description, she emphasized how the car's motion is both *going* down and faster, at the same time. She placed them in some kind of contingent relationship, without yet specifying its exact nature; for example, "going down" might entail "going faster" or they may simply happen together. At the same time, she described the car's motion as changing speed at distinct, albeit different, locations during various runs ("I saw *this* change in speed."). Change of speed in this light is not

so much continuous as discrete. In addition, she described the car's motion as gaining speed, then leveling out ("going faster up to about here"), presumably at some constant speed. The variability in Stacey's accounts does not reflect confusion; rather, each account is a possible and reasonable way of "seeing" the toy car's downhill motion.

At this point, Letisha introduced a new motion, pushing the car quickly down the ramp with her hand, not letting go. This motion contrasted sharply with the seemingly unaided motion of the car on previous runs.

2. *Letisha:* You can't just go like *[moves car swiftly down ramp holding it the whole way]* with your hand-force.
3. *Stacey:* I know yeah, cuz it doesn't go like *[moves car swiftly down ramp as L did]* like that. It just—you can't—it doesn't go like that *[repeats motion]* it can't—it goes slower and slo—and then faster then faster and faster and faster *[lets car run down ramp on its own]*.

Letisha's manipulation seemed to foreground for Stacey the shape of the car's trip as a whole. Agreeing with Letisha, she emphatically described the car's motion as progressively going faster and faster—in contrast with a fast and possibly unchanging speed under the control of one's "hand-force," as Letisha called it. "Hand-force" was a linguistic invention based in the class's earlier work with visible forces, to which they also gave names such as "arm-force" (i.e., in relation to a procedure they used to pull increasing numbers of boxes filled with equal amounts of copier paper).

We note a few qualities of the girls' accounts in lines 2–3. First, note how Letisha, in producing this new hand-forced motion, marked it as different from the car's unaided motion and, strikingly, as a violation of a previous pattern of motion (line 2, "*you can't* just go like . . . with your hand force"). Grammatically, the combination of the impersonal "you" and the modal "can't" delimit, in a generalized way, what is possible here and what is not under the given set of circumstances. In a related way, Stacey followed by saying that "it *doesn't* go like that," which acknowledges the reality that only certain things can happen here, but without committing fully to the generalized claim that Letisha put forward. Although different in force and scope, these two accounts are nonetheless fundamentally related in the way they construct what is possible and what is not in the world of the ramp.

Second, and in a related move, note how in her account Stacey shifted from the past tense ("got fast") in line 1 to the present ("it goes slower and then

faster . . . ") in line 3 to describe the car's change in speed, which accompanied her imitation of Letisha's hand-forced motion. This shift in tense foregrounds the change in speed as ongoing, not located in a single moment of change that takes place and then ends, but accumulating all the time. Like the characterizations of the hand-forced motion above, this way of describing the car's motion also emphasizes the generalized nature of this pattern, across time and place.

Third, note the pattern of repetition—"and then faster then faster and faster and faster"—Stacey used to describe the car's change in speed. The words themselves seem to speed up as they accumulate and as Stacey shifts from "*then* faster" to "*and* faster." This shift in markers from "then," which retains some quality of specific location and time, to "and," which is more general and not tied to a specific idea of time and place, seems to foreground Stacey's sense of the car's change in speed as being ongoing and progressive. It is interesting, perhaps, that as she began her account in line 3, she did the same sort of thing with "slower" and then quickly self-corrected. It is as if the idea of speed changing progressively—as contrasted with Letisha's hand-forced motion—now shaped what it is possible to see on the ramp. Letisha's action and way of accounting for the car's motion seems to have brought this realization into focus, namely, that the downhill motion of the toy car involves a progressive increase in speed over the whole length of the trip, a motion completely unlike that of hand-forced motion.

From here, Letisha, with Stacey joining in, embarked on a further, rather expansive exploration of the ramp and motion down an incline. Her approach was at once analytical and exploratory, combining a playful, imaginative attitude toward the material scene with a dogged concern to understand changes in motion in terms of the force(s) that might be causing them, as expressed in the formulation of Newton's ideas with which the class was presented. We note parenthetically that the children were only required to identify changes in speed, not to speculate on the possible force or forces that might be causing those changes. We pick up their interaction approximately 4 minutes after the introduction of the hand-forced motion.

31. *Letisha:* right, like with a real car what would happen was, well there's like a um like this thing that you like can turn–like can turn the wheels of the car and I mean there's like a wheel in the car that it can turn the car *[she slightly turns car at top of ramp, then lets go leaving car at top edge]*
32. *Stacey:* =yeah *[she picks up car and looks at its underside]*
33. *Letisha:* =or keep it straight. So (for a) turn(ed) car that's a ch—that's (just) forcing the car to change.

Just prior to this, Stacey had used Letisha's hand-forced motion, zooming the car down the ramp under the constant control of her hand, to show how it differed from the car rolling down the ramp on its own. Without hand-force, the car veered somewhat. Noticing this, Letisha invoked the motion of "a real car," in particular, the way in which a steering wheel functions to turn a car or keep it straight. She then began to draw out the implication of this observation, beginning this move in line 33 with "*so*...". Bumping up a register, she analyzed the event of "a turned car" in light of the Newtonian-inspired language circulating in the class: "so (for a) turn(ed) car, *that's* just *forcing* the car *to change*." Working creatively with this way of conceptualizing motion, Letisha forged a new object, "a turn(ed) car." This new entity fused the real car she was imagining, the toy car that veered on the ramp, and really any other "turned car" imaginable. In this way, Letisha made these instances of turning into a general case of change of motion, one that could be analyzed in a certain—that is, Newtonian—way. Let's look more closely at what she did.

We can see in Letisha's utterance the trace of her way of thinking. Note how in mid-utterance she interrupted herself—"so (for a) turn(ed) car that's a ch—." Presumably, she was about to say something like "that's a change in speed or direction," drawing on the formulation offered by Ms. Pothier. The presence of such a change would therefore imply the operation of a force or "something forcing that to happen." We suggest that Letisha interrupted her own train of thought at this point because she had already identified the change in motion in the object she had created, "a turned car." She "recognized" in this moment that the way this discourse functioned meant that she now had to infer a forcing mechanism, not the change in motion—in this case, the steering wheel as the something "that's just forcing the car to change." Indeed, in her analysis she unpacked the very nominalization she had constructed, making the action that is being explained explicit as well ("*that's* just forcing *the car to change*"), as if she was exploring for herself how this way of talking—or way of seeing motion—actually worked. In other words, Letisha was not speaking *through* Newton so much as *with* Newton, populating his ideas with her own intentions and accent (Bakhtin, 1981) and exploring the possibilities of this way of conceptualizing, representing, and evaluating the world of motion.

The object Letisha constructed, "a turned car," transformed the event or action of "turning" into a nominalization of the sort that has been identified as central to the character of scientific discourses (Gee, 1990; Halliday & Martin, 1993; Lemke, 1990; Myers, 1985). In the sciences, nominalizations are important for various reasons, including their status as fact (presumed to

be taken for granted) and the way in which they can organize the distribution and redistribution of information in a clause or organize other nominalizations within a classificatory system or other meanings within an unfolding argument (Halliday & Martin, 1993). We see Letisha working with a prototype of this way of using language. She created the nominalization, "a turned car," out of a felt need for this kind of generalized object, the need for which presumably emerged out of her insistent exploration of the language of force and motion put forward by Ms. Pothier. In this way, Letisha constructed a particular kind of object, one that identified a category of motion ("change in motion") that could then be subjected to a certain kind of analysis.

In Letisha's way of seeing, an ordinary, everyday steering wheel became subject to a different kind of analysis—it was no longer just a steering mechanism. It became as well a force, something that causes a change in a car's direction. As such, this everyday object and event also functioned as a generative tool for thinking and for provoking puzzlement—what forcing mechanism in or about the toy car might have caused it to veer or to change speed? Letisha's insight spurred Stacey's curiosity as well. In line 22, she took hold of the car and inspected its underside, presumably looking for some way to explain the car's behavior, absent a steering wheel. Thus, in Letisha's hands—understood both literally in terms of the actions she performed and figuratively in terms of the way she took hold intellectually of the challenge of a Newtonian perspective—ordinarily unlinked objects and events all became part of the same coherent world of ideas linking force and change in motion.

In the next segment, we see Letisha exploring this way of seeing motion further. Stacey had just given the car a push down the ramp, guided it back up the ramp, let it go so that it rolled back down, guided it back up again, let it go, then given it a push up the ramp. Letisha picked up on this new pattern of motion, lifting the ramp into a horizontal position in order to arrest the toy car's downward motion.

36. *Letisha:* wait *[S takes car off ramp]* I need to like hold on to it like *[she takes car back]* ( ) like this sometimes *[S releases car down ramp]* sometimes you go like that *[L lifts ramp to horizontal position, car continues to roll on ramp and on to rug]*
37. *Stacey:* =oh
38. *Letisha:* =the car won't stop
39. *Stacey:* yeah like this *[she places car at top, holding it, then releases it]*
40. *Letisha:* =sometimes it will like this *[L raises ramp to horizontal and car stops about midway]*

41. *Stacey:* yeah, //and sometimes *[gently lowering bottom of ramp so it slants again]* it won't stop
42. *Letisha:* //if you like tip it, if you ( )

In this scene, Letisha induced a stop in the car's motion by manipulating the ramp from a downward orientation to a horizontal one. Interestingly, this followed directly on her speculation about a "real car's" steering wheel causing changes in direction. She knew the toy car does not have the resources of a real car: steering wheels, brakes, and the like. But she also knew that whenever a car undergoes a change in motion, some force has acted to cause that change. Here she seemed to be exploring the ramp as a possible force that can cause a change in the car's motion, specifically to make it stop. Thus her meditations on the ways in which the motion of "a real car" may be changed created new possibilities for making present what was absent in the architecture of the toy car—a brake—through direct manipulation of the ramp. Through her action of leveling the ramp (line 36) and then tipping it (line 42), she explored the ramp as a possible force, bringing to life new ways of seeing it in relation to the toy car's motion.

Stacey was drawn into the possibilities created by Letisha's improvisational manipulation of the ramp. She, too, began to perform and interpret actions on it. In the following segment, Stacey reversed the slant of the ramp, from downward to upward during the car's run.

43. *Stacey:* ok *[she lets car run down as L maintains horizontal]* put it up—put it up like that *[she raises bottom end of ramp so slant is reversed]* and see what happens *[L raises bottom of ramp]* no no keep it down *[L lowers bottom end of ramp]* and when it gets *[S releases car and L reverses slant on ramp, car rolls back]* see it goes back *[L returns ramp to original position, S releases car down ramp]* and it doesn't stop, it just goes back
44. *Letisha:* That's because when—when you go up *[hits rug with hand]*
45. *Stacey:* =yeah
46. *Letisha:* you gonna have to come right back down *[she sweeps her arm over and down]*
47. *Stacey:* yeah when you go up *[she slants ramp at a greater angle, bottom now the top, facing L, moves car up ramp]* and you—when you go up and it's—when a toy car goes up *[S guides car up ramp, then down]* then without an extra push *[S guides car up ramp, then down]* it can't stay going up, right?

In line 43, Stacey explored what would happen when the slant was reversed ("put it up like that and see what happens"). Then, when the car rolled back, she was not at all surprised ("*see*, it goes back and it doesn't stop"). Although Stacey seems to have anticipated this outcome, it also struck her with new meaning in the contrast it made with Letisha's horizontally positioned ramp, which effected a stop in the car's motion. Letisha immediately offered an account of this particular pattern of motion with an analysis which, in her use of the second person pronoun "you," merged the motion of the toy car with a larger universe of objects or persons that can undergo the same motion and obey the same imperative, lines 44–46: "that's because when you go up, you gonna have to come right back down." Agreeing, Stacey then suggested in line 47 that "without an extra push, it can't stay going up . . . ". As she spoke, she moved the car under control of her hand up and then down the ramp, as if to suggest the need of a continuous push or force to keep the car "going up." In their actions and interpretations throughout this episode, both girls intently explored the central mystery of the car's downhill motion: the absence of a visible force that can explain various patterns of change in the car's speed.

Like Letisha, Stacey linked the language of force ("without an extra push") to a change in motion (from going down, which it will do in the absence of an intervening push, to going up). Indeed, her language—"without an extra push, it can't stay going up"—reflects her growing appreciation for this way of seeing motion. First, it underscores the loss of upward motion resulting from the absence of an added force (". . . it *can't stay* going up"). Second, Stacey framed this absent "extra push" as a force that, implicitly, can work against whatever is making the car change its motion from going up to going down, as she said, to "*stay* going up." There is a certain inventiveness in Stacey's use of language here ("can't *stay going up*"), which may be read as awkwardness, but which, we suggest, reflects instead her emerging sense of the necessary relationship between force and change in motion. The insights of both girls seem anchored in their sense of how things go in the everyday world and in Newton's world, and in their efforts in the here-and-now to work out new possible meanings for previously familiar, ordinary events. The "familiar" has become intriguingly "strange," and at the same time accessible to analysis.

Agreeing, Letisha then likened these cases of motion to a baby carriage on a hill.

48. *Letisha:* mmhmm, like when a baby carriage is up on a hill, you need to turn on the brakes *[L places car part way up on ramp, as if up on a hill, and holds it there]* so it can stop

49. *Stacey:* =yeah yeah
50. *Letisha:* =so it won't li—like move
51. *Stacey:* cuz if a toy car stops, like this *[she re-creates uphill ramp, holds car on ramp]* it's—if it stops *[she moves car to a position on the ramp about halfway up, then releases it, it rolls down]* then it's gonna move right back cuz it doesn't have any control, right?
52. *Letisha:* Mmhmm

In this segment, Letisha and Stacey collaborated on the creation of an imagined scene in which baby carriages on hills and toy cars on ramps illuminated the case of stopping as a change in their otherwise inevitable downward motion. Both girls moved the car on the ramp in synchrony with their talk, as if they were thinking with and through the physical environment of the ramp and car. Indeed their respective actions—Letisha held the car partway up on the ramp and Stacey moved it halfway up the ramp and then released it—together form a whole for the situation they were exploring: the presence and absence of a force to counter the descent of the car or baby carriage.

We can see in the structure of Letisha's language how she was seeing the car's motion in terms of the relationship linking changes in motion, including stopping, to the action of a force. Note, for instance, how she connected stopping ("so it can stop") with a change in motion ("so it won't like move") through use of parallel structures; in this way, she equated "stopping" with the negation of the baby carriage/toy car's downward state of motion—from "moving" to "not moving," in other words. Likewise, we can see Stacey elaborating Letisha's earlier law-like pronouncement (lines 44–46, "when you go up you gonna have to come right back down") with a mechanism of presence or absence of control: line 51, "cuz if a toy car stops [on a ramp] [letting go] then it's gonna move right back down cuz it doesn't have any control, right?" The toy car, unlike real cars and baby carriages, does not contain the means to control its motion or, implicitly, to counter the otherwise inevitable downward motion on a ramp. In these children's hands and mind's eye, real cars and baby carriages have the power to illuminate something important about toy cars and vice versa. In this world of ideas about motion and force that they were exploring, brakes on baby carriages function much as hands do in controlling the downhill motion of a toy car; both are seen as potential forces that change the motion of the vehicle's descent from moving to not moving.

Throughout this episode, Letisha and Stacey brought together the world of the ramp and the "everyday" world of real cars and baby carriages. They

used familiar objects and events analytically in their playful and speculative investigation of the ramp. They worked improvisationally, recasting objects (e.g., a turned car, baby carriages as toy cars) and unfolding events (e.g., downward motion turned into stopping), opening up new paths as they explored the possible meaning of Newton's ideas in relation to their lived experience of motion on and beyond the short ramp and toy car in front of them. As they did so, they both inhabited the world of the ramp and toy car—creating new scenes, experimenting with new actions within it—and treated it as an object of analysis in its own right, as a world of motions and, especially, changes in motion that in theory could be accounted for, even if the precise mechanism seemed, for the moment, not obvious.

Elton

Two days later in a whole-class discussion, the children shared their accounts of changes in the toy car's speed. They related the motion of the toy car to their own bodily experiences running down ramps and hills. In relation to those experiences, they built descriptions of patterns of change in the toy car's speed over the course of its trip. We focus on the contributions of a second grader, Elton.

The first episode occurred about 17 minutes into the approximately 40-minute class. After one pair of students described how they thought their car "started to get faster" in the middle and reached its full speed near the end of the ramp, Elton suggested that the car's motion down the ramp is "sort of the same thing" as running down the ramp at the back of their school:

1. *Elton:* Um putting the car um down the ramp is sort of the same //(thing)
2. *SP:* //I can't hear you
3. *Elton:* putting the car down down the ramp *[points to another child's ramp with left hand]* is sort of the same as you running down the ramp *[makes quick waving motion with same hand]* because (.) (not only) if you're in a car you go down a ramp *[quickly angles left hand from left to right]* you could feel how it's going faster but also when you run down the ramp you could feel getting—when you're running faster *[walks fingers of right hand at a descending angle from right to left]* ( ) (getting faster) *[arcs left hand right to left at eye level]*

4. *SP:* So you've noticed your experience running down a ramp. How many people have run down a ramp outside, you know the ramp to go to the playground? *[many hands go up]* So tell us again what you've noticed Elton.
5. *Elton:* Um if a—if a car—if a car could get faster going down a ramp *[angles right hand down from right to left]* you could because um um when you get down and down *[repeats gesture]* it makes your legs go faster *[revolves hands in a rolling motion]* //um
6. *SP:* //Mmm. What did other people notice when you're running down a ramp? Do you go faster when you're running down a ramp?

Let's focus on what Elton did here. Like Letisha, Elton brought together varied contexts of motion, proposing that they are "sort of the same": the toy car on the ramp, a person in a real car, and his own experience running down a ramp (lines 1 & 3). He then went on to show how. He imagined himself into a real car, going down a ramp in some unspecified time and place (line 3: "if you're in a car, you go down a ramp"). Imagining himself in such a car, he can "*feel* how it's going faster." At the same time, he narrated his experience of running down the ramp (line 6: "but also when you run down the ramp"), presumably the very one at the back of his school that he has run down many times before. For both the real car and his running, Elton imagined himself into these scenes, emphasizing the *feeling* one has in the midst of going down. He used the conditional "could" emphatically, which underscores the sense of his having discovered a similarity in the two cases: the *feeling* one has as the car one is in or one's body *goes* or *gets faster*. In other words, "could" conditions the experience of *feeling* one's speed increase, rather than the possibility of increasing speed: This feeling of one's speed increasing is *evidence* for the ongoing increase in speed, what one would feel in such situations, the very same feeling of increasing speed. The fact of increasing speed itself Elton here took as given.

As he spoke, Elton experienced the motion in his arms and hands. He performed this relationship of going down and going faster with gestures of his hands and fingers, his left and right hands becoming at once inclines and objects gaining speed. These performed gestures linked both lived and imagined experience; both were brought to life in the unified motion of his hands. We draw attention to this because in this way of using his body, we see Elton both imagining these scenes through his body—"feeling" what it is

like to go down in a car and as he runs—and thinking with his body about what makes them similar—the resulting change in speed. Like Letisha and Stacey, he was both inside and outside these scenes, inhabiting them and also evaluating them. He saw them as part of an encompassing relation, continuous change in speed: going or running faster the farther down one gets on a ramp. What Elton noticed and explained, as Letisha had when she connected baby carriages on hills with toy cars on ramps, is that these two events are in some important sense part of the same *family* of motion (Wittgenstein, 1953).

Asked to repeat what he noticed, Elton (line 5) further elaborated the similarity in these motions: you *could* get faster just like a car *could* because going "... down and down ... makes your legs go faster." The "coulds" in this case again seem to us to be functioning as they did before, not so much to mark a conditional status as emphatically to mark the similarity he is noticing—getting faster—which he then went on to link to the experience of "going down and down." Something about his sense of the car's experience helped him to see running down a ramp in a new light and vice versa, a light that seems influenced by the circulation of Newtonian ideas, albeit more implicitly than in Letisha's case. Both the car and his running became yoked together as experiences of "going down and down," which "make(s) your legs go faster." Indeed, in this moment, real cars, toy cars, and bodies running were folded into one image, as Elton simultaneously rolled his hands one over the other in a gesture that fused both wheels turning and legs churning. His hand motion synthesized these experiences into the same pattern of downhill motion.

In Elton's hands, these two worlds—the toy car on the ramp and his body running down a ramp—interpenetrated in a way that made the familiar experience of running down a hill seem strange in the light of new, emergent possibilities of meaning, new ways of seeing. Surely Elton already knew in some sense that as he ran down a ramp he got faster. But here, like Letisha, he seemed to experience it in a new way, to be exploring it from a new perspective, to be noticing new aspects (Wittgenstein, 1953). Indeed, Elton's way of bringing these two instances of motion together seems to have illuminated for him something about the experience of going "down and down" in relation to "going faster." This comes through in the way he explicitly linked the experience of covering distance on the ramp ("when you get down and down") with increasing speed ("it makes your legs go faster"). He seems to have developed a feel for how this kind of trip unfolds, as one involving some ongoing sort of change as one goes "down and down," and a feel for what "go faster" means in these two now fully linked situations. Like Letisha and Stacey in the previous class, Elton explored the ramp as a place in which to bring together various

situations and to bring to life new ways of seeing these, that is, as belonging to the same family of motion, in which both cars and people get faster and faster as they progress down an incline.

Synopsis of Subsequent Investigation

Spurred on by the generativity in Elton's contribution, Ms. Pothier elicited other children's experiences with motion down a ramp. Their accounts of these experiences turned out to be richly varied. Like Elton's, these accounts did not merely replicate the given of their prior experience but created new possibilities for noticing connections between aspects of change in the speed of their bodies and the toy car, among them: a pattern of increasing speed from slow to fast to faster, which one boy described as a reversible pattern of walking, jogging, and running, depending on whether you were going down or coming off the ramp; the effort they needed to exert to slow themselves down as they neared the bottom of a ramp; and the difficulty of stopping at the bottom.

Under Ms. Pothier's guidance, the children built on their initial intuitions and insights to investigate more closely the toy car's downhill motion and analogous motions of their bodies. In their initial explorations, a few students noticed that speed was related to the force of impact when the car collided with some other, fixed object (e.g., a ruler, one's hand). Ms. Pothier built on these noticings to create a systematic and publicly shared way to assess the car's changing speed, which she called a "speed test." She introduced a much longer ($\sim 7'$) ramp to allow for a longer trip and easier comparison of speeds, and attached a length of Hot Wheels™ track to the ramp to better control the car's motion. She had the children hold a small wooden block at successive locations on the ramp—initially near the top, middle, and bottom—to stop the car's motion. The children worked with this "block test" in whole-group and small-group contexts for several classes. We briefly describe their work in order to give some flavor of how this investigation continued to take shape and how the children's understanding of the toy car's motion continued to develop.

The "block test" allowed the students to collect multiple kinds of data on the car's speed. Besides being able to feel differences in the force of impact as they moved the block to successively lower locations on the ramp, they were able to observe how the block and their fingers responded to the car's impact and to notice differences in the sound made by the impact. They easily associated relative changes in each effect to corresponding changes in the car's

speed. Alicia, for example, said, "I think it's [the car] sort of the fastest down here [near bottom of ramp], because it's knocking (the block) all the way down to the end... Right at the beginning it was only knocking my finger a little bit forward." They brought strong intuitions that the force of impact increases with speed. In these ways, the block test provided the students with a perceptual practice for "highlighting" (Goodwin, 1994) the car's speed at different points in kinesthetic, visual, and audible form. It helped to make visible and specify their emerging intuition that the car's speed was increasing positively and continuously as it traveled down the ramp.

What sense did the students make of their encounters with the block test? In practice, the block test yielded a series of successive "snapshots" of the car's instantaneous speed at three or more discrete points during the car's trip. During the first of many classes organized around the use of the block test and interpretation of its results, one boy, Ken, commented on his experience holding the block at successive positions. He focused especially on the impact at the bottom, which was visibly greater than at the other positions as the car knocked the block out from under his finger and sent it a short distance across the rug. Ms. Pothier asked Ken to report on his experience:

Ken: I sort of felt when the car hit it, I sort of felt the um block go up a little and hit my other finger and um I think that—I think that means that the more the car goes down the track *[dragging his finger down the track from about 2/3 of the way down the track to near the end]* the more it gets faster.

Here Ken, in an echo of Elton's "going down and down," interpreted the block test results to mean that the car's speed increases continuously as a function of the distance it travels down the ramp: "I think that means that the more the car goes down the track, the more it gets faster." As he spoke, he dragged his finger from an area between the middle and bottom test locations down to the third and final spot, to emphasize the car's motion as an *ongoing* process of "get(ting) faster." Merging car and body in this way, Ken extrapolated from the three discrete data points used to perform the block test to fill in the positions between those points with a continuous series of incremental speed changes, as he would have observed had the class applied a series of block tests to the whole length of the ramp.

The students worked with the block test as well as other speed tests for several weeks to refine their sense of how the car moved on the ramp. At the end of this sequence of classes, many of the children gave evidence that they

were thinking of the car's motion down the ramp in terms of continuously and positively increasing speed. In a discussion they had toward the end of May, the students shared their views of the car's motion down the ramp. Here is a sample of what they said:

> "... the more the car goes down the track, the more it gets faster." [Bill]
>
> "We discussed [in their partner work] that it was fastest at the end, because the speed builds up at each place." [Juan]
>
> "At the beginning it [the car] is just getting speed, in the middle it can still get speed because it has more time, but at the end there's no time left to get more speed." [Tina]
>
> "I think it [the car's speed] builds up at each place. It goes up from the beginning to the end." [Gregory]

The children came to see the car's speed as continuously and positively changing. These students, like Ken before them, suggested that "getting faster" is a *function* of aspects of its ongoing motion (e.g., how far down the ramp the car travels, how long it has been moving, successive positions). Their accounts constituted for them a new language for describing downhill motion, a new way of seeing what literally cannot be seen. In this sense, these later accounts of downhill motion seem as much a *model* of a kind of motion as they are inferences based in their observations and experiences. Having established this pattern of motion for the car on the ramp, Ms. Pothier and the children went on to explore it further in light of Newton's ideas. They grappled with gravity as the force responsible for the car's downward acceleration.

DISCUSSION

We opened this chapter by questioning the value of a dichotomous view of modes of thought in the study of human experience and learning. In such treatments, the mode of "everyday thinking or experience" is viewed negatively, as lacking the logic, rigor, abstractness, power, and precision of the more highly valued mode of "scientific thinking." In one of the more trenchant critiques of this tradition, Lave (1988) argued that "everyday thinking and experience" is for the most part viewed residually, in contrast with "scientific modes of thought," rather than as a phenomenon in its own right. It is also understood as largely static, residing in one's past, rather than being constructed in the present as an immediate relation between persons acting and the social world within which they live.

In this study, we have taken the dichotomy of "everyday experience" and "scientific thinking and knowing" to be problematic. In the traditional contrast, "everyday experience" is viewed negatively, as a residual, static storehouse of past, fully digested encounters not possessing analytic power. Through our analyses of the activity and talk of Letisha, Stacey, and Elton, we have sought to show that these children's accounts of their experiences in the world were not mere replications of those experiences, but instead newly interpreted, in-the-present encounters, shaped by emerging insights, experiences, and intentions. Indeed, through their actions—both physical and analytic—in and on the world of the toy car and ramp, these children generated various possibilities of meaning for motion down an incline. In the process, they subverted the ordinary meaning of their life experience (e.g., real cars, baby carriages, hills, and ramps); they recast objects and unfolding events in new terms, creating new possibilities for analysis and understanding (e.g., a car's steering wheel as a force causing a change in motion, one's body on a ramp experiencing the same pattern of motion as a car on a hill); they played with outcomes, creating new structures for comparison across many situations of motion (e.g., comparing different orientations of the ramp) and populating Newton's ideas in varied ways (e.g., seeing change in motion as encompassing many possibilities, including an increase in speed, a negation of motion as in a stop, a change in direction from up to down, increasing speed as a function of distance traveled).

The putative distinction between "everyday" and "scientific" comes apart, in our view, in the face of accounts such as those presented here that detail the complex ways in which the children brought into contact the world of their lived experience, the world of the ramp, and the world of Newtonian ideas. Bakhtin (1981) called this process of bringing different perspectives into contact "interanimation," which is rooted in the fundamentally heteroglossic nature of language. This means that within a given national language (e.g., English), there are always many different ways of speaking, each reflecting different ways of conceptualizing, representing, and evaluating the world.

> (A)ll languages of heteroglossia... are specific points of view on the world, forms for conceptualizing the world in words, specific world views, each characterized by its own objects, meanings and values. (Bakhtin, 1981, p. 292)

Newtonian physics is thus a language in this sense, a specific way of conceptualizing, representing, and evaluating the world. Likewise, our everyday ways of talking about cars, brakes, and steering wheels is a language in this

sense. Bakhtin (1981) illustrated this point with an admittedly oversimplified image of a hypothetical peasant:

> Thus an illiterate peasant, miles away from any urban center, naively immersed in an unmoving and for him unshakable everyday world, nevertheless lived in several language systems: he prayed to God in one language (Church Slavonic), sang songs in another, spoke to his family in a third and, when he began to dictate petitions to the local authorities through a scribe, he tried speaking yet a fourth language (the official–literate language, "paper" language). All these are *different languages*... But these languages were not dialogically coordinated in the linguistic consciousness of the peasant; he passed from one to the other without thinking, automatically: each was indisputably in its own place, and the place of each was indisputable. He was not yet able to regard one language (and the verbal world corresponding to it) through the eyes of another language (that is, the language of everyday life and the everyday world with the language of prayer or song, of vice versa). (Bakhtin, 1981, p. 296)

This image is oversimplified in that a total absence of dialogic coordination in the linguistic consciousness of the peasant is not really possible. For Bakhtin, dialogism is the necessary condition of language use and meaning in a world dominated by heteroglossia. It indexes the ways in which languages are always already in contact, attracting accents and meanings from each other in ways that may be complementary, contradictory, revelatory, and so on. Bakhtin helps us see the nature of this "dialogized heteroglossia" (Morson & Emerson, 1990), again through the experience of his peasant.

> As soon as a critical interanimation of languages began to occur in the consciousness of our peasant, as soon as it became clear that these were not only various different languages but even internally variegated languages, that the ideological systems and approaches to the world that were indissolubly connected with these languages contradicted each other and in no way could live in peace and quiet with one another—then the inviolability and predetermined quality of these languages came to an end, and the necessity of actively choosing one's orientation among them began. (Bakhtin, 1981, p. 296)

Let us focus on this idea of interanimation, specifically, how it relates to the learning of Letisha, Stacey, and Elton. As a word, "interanimation" is not especially felicitous. It is not as well-known a term as some others found in Bakhtin's corpus to which, as we explained above, it is fundamentally related (e.g. dialogic, heteroglossia). Yet in its main parts it conveys a great deal: first, the kernel of "animation," which suggests bringing to life or filling with life, and second, the prefix "inter," which suggests between-ness or mutuality. When Letisha forged "a turned car" as a new object for analysis, she was operating at the boundary of the mundane world of real cars and steering wheels and the specialized world of Newtonian ideas. She brought to life a

new object subject to a specific form of analysis. At the same time, she explored this Newtonian way of conceptualizing, representing, and evaluating the world for its analytic potential. She was in both of these senses actively orienting herself among these various languages, inhabiting as well as evaluating them. Elton did this as well, as he noticed and analyzed how a toy car's motion on a ramp and his own motion running down a hill were similarly patterned.

As we are using it, interanimation means bringing into contact realms of experience and ideas, ways of making sense of the world that are not normally in contact (e.g., baby carriages and Newton's Laws) or that are viewed as not capable of productive contact (e.g., as in the dichotomies formulated around modes of thinking discussed at the outset of this chapter). Through a process of interanimation, meanings that are otherwise taken for granted as understood (e.g., Goody's folk taxonomies), whether one's lived experience with downhill motion or a scientific law, are destabilized. In these encounters, the engaged realms of experience and ideas become objects of inquiry *for* each other, as they did for Letisha, Stacey, and Elton. In such a process of critical interanimation, new possibilities of meaning, new objects, new ways of seeing, new questions, new ways of bringing order into the complexity of experience are brought to life.

Interanimation, therefore, denotes a process whereby a person comes to regard one way of conceptualizing, representing, and evaluating the world through the eyes of another, each characterized by its own objects, meanings, and values. As such, it resists the strong temptation to dichotomize modes of thinking or being. As human beings, we inhabit many such ways of seeing, talking, acting, reading, writing, and valuing as we go about our daily lives. In the sciences, as in any academic domain, learners are asked, usually not explicitly, to orient themselves actively among varied—sometimes conflicting, sometimes complementary—ways of conceptualizing, representing, and evaluating the world and the possibilities these present for making sense of the world. Interanimation thus involves what we view as a creative struggle—the active coordination of different ways of seeing, talking, valuing in the course of learning in a domain such as physics. In the study reported here, children actively coordinated their "familiar, everyday experience" with downhill motion and "unfamiliar, scientific ideas" in the context of inquiry into the motion of a toy car rolling down a ramp. In their efforts to coordinate these worlds, real cars, bodies running, toy cars, baby carriages, hills, ramps, brakes, hands, and scientific ideas about motion served as sources of insight for each other, with perspectives, questions, and details from each giving shape to the emergent ways in which the children conceptualized, represented, and evaluated

the nature of motion down an incline. As their work attests, the presumed boundary between "everyday experience" and "disciplinary ideas" blurred as the children both inhabited and analyzed the hybrid worlds they had created, opening up new paths to meaning and new ways of seeing in the process.

We conclude by reflecting further on Letisha and drawing out some of the wider implications of this study, as we see them. Letisha was repeating second grade the year of this study. Overall, she was not seen by the school as a "strong" student. She is African American, from a working class household. She had been identified by institutional practices as needing special attention for what were deemed "language difficulties," an all-too-frequent classification of African American children from low-income or working class households. We noted in the introduction that from a discontinuity point of view, children from historically underserved communities may be especially disadvantaged because their "everyday" experiences and ways with words are viewed as being the furthest from—or incompatible with—those conventionally valued in science (O. Lee & Fradd, 1996; O. Lee, Fradd, & Sutman, 1995). We might wonder, then, how Letisha's expansive way of thinking about downhill motion might be understood by teachers and researchers inclined to see learning through the lens of traditional dichotomies? Indeed, in presentations we have made of the Letisha and Stacey episode, some in the audience have valued the contributions of Stacey and Letisha quite differently. Some have, for example, viewed Stacey as being explicitly focused on the task at hand (a positive feature) and Letisha as going outside the boundaries of the task (a negative feature). Some have suggested that Stacey was working with "more abstract" concepts than Letisha, an interpretation entirely unsupported in the analysis presented here. Interpretations like these can have very large, enduring consequences for children, for how they are taught, how they are perceived, and how they perceive themselves as learners and thinkers, especially if their sense-making efforts are repeatedly judged as not centrally relevant to the academic matters at hand.

Our analysis of Letisha's work in the focal episode leads, without question, in another direction. But we—the authors of this chapter, both teacher and researchers—had to work at learning to see and hear the intellectual substance in Letisha's talk; our understanding did not come automatically. Both Ms. Pothier and the researchers, all Euro-American with advanced education degrees, found Letisha hard to understand initially; we found it difficult to follow her reasoning. She often seemed to be answering a different question from the one asked. However, rather than assuming that the problem resided in Letisha—in something about the way she thought or spoke, in some deficit

in her background of life experience, or in the incompatibility of her ways of knowing with those valued in the sciences—we assumed that the problem resided in *our* norms of interpretation, in *our* assumptions and expectations regarding what counted as a meaningful response to the teacher's questions; in other words, in our own trained inability to see and hear the intellectual substance of Letisha's discourse.

We began at this point to examine Letisha's classroom talk closely, as well as our responses to it, by studying videotapes and transcripts from the unfolding investigation. The more we focused on the sense she was making and its potentially deep connections to the scientific matters at hand and the more we opened our assumptions of what counts as scientific to scrutiny, the clearer Letisha came into view as a big, rather than muddled, thinker, as a child who went at questions from an integrated, often speculative, "big idea" perspective in order to make sense of the relations among ideas, objects, and events she encountered in her life and in school. Letisha engaged with ideas she encountered in school through what we now understand to be a process of critical interanimation, analyzing and exploring their potential meaning across the many settings of her life, which initially had confused us; she worked at seeing one way of conceptualizing the world through the eyes of another. With this view of Letisha in hand, we became able to see and hear her as a child who sought to be engaged intellectually with the large questions and conceptual frameworks of the domain of study. Ms. Pothier who, prior to our investigation of Letisha's sense-making was concerned about what she was actually understanding, tended to ask her increasingly narrower questions to assess what she knew or did not know, shifted her way of engaging with Letisha. She now elicited more expansive comment from her, as she did with other students she saw as academically competent. As a result, Ms. Pothier also had more access to Letisha's thinking and concerns. As Letisha expressed her ideas more expansively, she also opened up for others—the teacher, other students, the researchers—perspectives on the subject matter of profound significance to the discipline. We see in detail how she did this for Stacey, who, we note, was by all conventional measures an academically successful student.

Thus, the question of the intellectual value of "everyday experience" and "everyday ways of knowing or talking" is not merely a theoretical matter. How we, as researchers and teachers, view the sense-making resources that children bring from their backgrounds of life experience will have very real consequences for how children are able to participate in science. As we have tried to show, Letisha brought various realms of experience and ideas into critical interanimation. She sought out the connections between these and sought to

see them as part of an encompassing view of the physical world of motion. The "everyday" world of her experience, far from being a barrier to understanding Newton's ideas, was a profoundly generative source of objects, events, questions, insights, and construals, which she constructed as part of her encounter with the toy car on the ramp and Newtonian ideas. At the same time, she literally and figuratively took hold of Newtonian ideas as a way to recast the objects and events of her lived experience. She populated these ideas with meaning and intention, creatively inventing ways of talking about motion and ways of "forcing" a change in motion. In so doing, she explored the power of these ideas to explain various experiences of motion. Stacey and Elton explored the toy car's motion on the ramp in similar ways. For her part, Ms. Pothier encouraged the expansive and analytic orientation the children took to their lived experience and Newton's ideas in their study of the physics of motion. She did not bracket their experience as a mere preface to the main work, but engaged it as a central object of inquiry on the same plane with Newton's ideas.

The task learners face is to populate new ideas they encounter with their own intentions and accents, while also coming to grips with the contextual overtones—situated meanings and uses—with which they are already saturated, such as those valued in the discipline (Bakhtin, 1981). This process of appropriation involves the active coordination of multiple ways of conceptualizing, representing, and evaluating the world. It underlies what we recognize as learning. In probing meaning in and across varied contexts, perspectives, objects, events, and ideas, the children in this study began to appropriate Newton's ideas in just this way. Neither Newton's ideas nor their lived experience uniquely disciplined their perception. Rather, their understanding and questions emerged in the interanimation between these, proof of which are the hybrid worlds they created on the ramp, living in them as well as standing outside them in order to populate them with meaning.

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