11 Science, Culture and Equity in Curriculum

An Ethnographic Approach to the Study of a Highly-Rated Curriculum Unit

Joel Kuipers, Gail Brendel Viechnicki, Lindsey A. Massoud, and Laura J. Wright

Introduction

Considerations of student diversity in K-12 settings often center on within- and between-group comparisons of students of different cultural and linguistic backgrounds. In this chapter, Kuipers and his team use and describe an innovative approach in their consideration of diversity in science classrooms; they examine “diversity in practice rather than diversity in label.” Specifically, these authors argue that a simplistic examination and performance categorization of “how the black kids did” or “how the Latino kids did,” for example, may not fully capture the differential experience that may be afforded by participation in heterogeneous small group collaborations with innovative curricular materials designed to more fully invite all students into science learning. Instead, the authors consider the opportunities provided by unfolding heterogeneous small group interaction with the curriculum to understand what is meaningful to students as they participate in science learning. They encourage us to focus on the diversity of students’ personal experiences in the classroom, rather than the diverse identities of students themselves.

In order to document students’ personal experiences with a reform science curriculum, the authors analyzed specific ethnographic and linguistic dimensions of students’ talk, writing, and interactions and also examined dimensions of the reform curriculum unit including its narrative structure, organization of lessons, and opportunities for reasoning and reflection. This close examination of the juxtaposition of students’ personal experiences and the science materials allows for a deep understanding of the science-learner identity opportunities presented by reform science curricular beyond the surface-level characterization of those opportunities in the materials. The authors push us, in this chapter, to see how well-designed curricular materials do indeed interact with who children are, and what they know and bring to their science learning.

As you read through this chapter, think about how you have learned to
analyze the benefits of science curricular materials. What were the dimensions along which you examined the unit(s)? In what ways did the materials or the information provided to you encourage consideration of the different kinds of science learner identities, like personal experiences and knowledge, that your students might bring to the classroom? In what ways did the curricular materials or your implementation of the materials awaken you to the possibilities inherent in organizing and supporting diverse experiences in the classroom in support of science learning? After you read this chapter, think about how you might modify or supplement instructions and materials in science curriculum to offer opportunities for students to meaningfully relate to science learning and to usefully leverage the presence of other learners as they engage in science sense-making and science learner identity development.

Philip is an African American boy in an ethnically-diverse middle school science classroom who appears to enjoy the subject. He likes to be the one with the answers. His lab table partners—Sean, a European American boy, and Natalie, a Latin American girl—find him annoying. As they prepare to weigh a mixture of vinegar and baking soda for an experiment, Sean confirms the next step under Philip’s watchful eye. Table 11.1 contains a transcript of their exchange.

Sean, often appearing apathetic and unprepared for class, uses a technical-sounding phrase to describe their task: “First we have to do the before weight, right?” Philip, challenged by Sean’s assertive display of this unusual phrase, moves to re-establish control and reaches for the scale. Natalie, watching intently, focuses instead on the task of recording the results. A step ahead of the boys, she notes the weight of the scale—“one oh four”—and proposes what they should write into the workbook as an answer, further challenging Philip’s authority. Philip gets control of the procedure again with two unusual expressions: “there might be a slight difference” and “there’s the lid weight that we need right now.” In the end, he overrules Natalie, and gains interpretive rights over the experiment from Sean. In line 12, Sean asks Natalie how much the mixture weighed—essentially, what they should write down on their worksheets. In line 16, Philip wonders about where to write that number down on their worksheets and Natalie points him in the right direction. Philip then notes that the mixture has continued to lose weight, and reads the number from the scale out loud in line 18 (“point three”) and Natalie makes sure that Sean has the right number to write on his worksheet (line 20).

Thousands of such mini dramas occur in schools each day all over the U.S., and, indeed, throughout the world. Most, however, do not occur in a curriculum unit that yielded such impressive results as this one. At the conclusion of this eight-week unit devoted to exploring the idea of conservation of matter, the students did not like Philip any better. But they all participated. Sean used expert expressions, Philip got to handle the equipment, and Natalie did much of the recording. And these acts of participation were not unusual: in the seventeenth
largest school district in the country, this curriculum unit, titled *Chemistry That Applies* (CTA), not only raised outcome scores overall, but significantly narrowed achievement gaps between traditionally well- and under-served groups. As Figure 11.1 shows, children who were classified by the school district as eligible for Free And Reduced-Price Meal System (FARMS), or who were formerly so classified, showed the greatest improvements in relation to the comparison condition (i.e., children who received a curriculum unit unrated by the American Association for the Advancement of Science (AAAS)).

In this chapter, we take the notion of equity further than disaggregated outcome scores, although these analyses are certainly revealing. In examining how the curriculum works for the students, we describe how differences in participation characterize student diversity in terms of what is meaningful to students—what they actually do within the classroom. We describe, ethnographically, manifestations of diversity in student practice, and further aim to understand how this diversity, in the context of a highly-rated, hands-on curriculum unit, can be drawn upon to increase student achievement in science.

In examining one particular curriculum unit, however, we are not interested in performing a curriculum evaluation; this has already been done by the AAAS

### Table 11.1 Transcript

<table>
<thead>
<tr>
<th>Transcript</th>
<th>Student activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. S: Okay but weigh it all first- we have to do the before weight, so I’ll pour this in now, right?</td>
<td>Philip – lab procedure (holds plastic bottle)</td>
</tr>
<tr>
<td>2. P: Yeah. Pour it.</td>
<td></td>
</tr>
<tr>
<td>3. N: Why don’t we just put-</td>
<td>(can’t see activity; Sean is standing in front of table, but he seems to be holding objects)</td>
</tr>
<tr>
<td>4. P: Hey- Yeah put that in but don’t put it- put the stuff in.</td>
<td></td>
</tr>
<tr>
<td>6. P: What?</td>
<td></td>
</tr>
<tr>
<td>7. N: Okay it says one O four, that’s before, so why don’t we just- it’s going to be the same thing.</td>
<td></td>
</tr>
<tr>
<td>8. S: No- it might be different.</td>
<td></td>
</tr>
<tr>
<td>9. P: It can’t- there won’t- there might be a slight difference, but we should- so we should be sure.</td>
<td></td>
</tr>
<tr>
<td>10. S: That and we should put the lid- we should put the lid on here.</td>
<td></td>
</tr>
<tr>
<td>11. P: Exactly sure. Plus there’s- and there’s- there’s the lid weight that we need now.</td>
<td></td>
</tr>
<tr>
<td>12. S: Okay, how much is it?</td>
<td></td>
</tr>
<tr>
<td>14. P: Yes.</td>
<td>Philip – lab procedure (puts lid on the scale to weigh it)</td>
</tr>
<tr>
<td>15. S: One sixteen point four.</td>
<td></td>
</tr>
<tr>
<td>16. P: Where do we put that? This- side.</td>
<td></td>
</tr>
<tr>
<td>17. S: XX.</td>
<td></td>
</tr>
<tr>
<td>18. P: Point three.</td>
<td>Natalie – clean up (uses paper towel to wipe water from the table in front of the scale)</td>
</tr>
<tr>
<td>19. S: One sixteen right?</td>
<td></td>
</tr>
</tbody>
</table>
Project 2061 team. Instead, we are providing a linguistic and ethnographic interpretation of how this curriculum unit functioned in its social and cultural context of use. Drawing broadly on the criteria for instructional support formulated by AAAS Project 2061, we examine CTA by Michigan State University as it was implemented in a diverse middle school classroom in suburban Washington DC. Adopting the students’ perspective, we seek to understand how middle school learners experienced the content, goals, and organization of these curriculum units, as well as the relation of the “official, manifest” curriculum texts to the students’ own, informal sense-making practices. Among these latter practices are (a) use of the scientific register, or “talking science”; (b) object manipulation that provides students with direct experience of relevant scientific phenomena; and (c) graphic representations of knowledge through literacy practices, or reading and writing.

American educational theory has a long history of placing importance on student experience in learning. According to the National Research Council (1999b), for children to learn, crucial features of instructional support include: “adults who direct children’s attention, structure experiences, support learning attempts, and regulate the complexity and difficulty levels of information.” Given the importance placed on instruction as the organization of experience, it is surprising how “little empirical and conceptual work has directly considered student experience” in the analysis of curriculum. Our paper seeks to address this gap by proposing specific ethnographic and linguistic dimensions for interpreting students’ own multimodal sense-making practices. By focusing on
student participation, we emphasize diversity in practice rather than diversity in label. In addition to discussing categories that are usually used for disaggregating test scores, such as race, socioeconomic status, and language abilities, we examine how students themselves interact with a curriculum unit in different ways. Diversity can manifest in a number of ways in education and social life more generally and is not merely a collection of categories. We examine diversity here in how students experience it—as differences in participation patterns within the classroom. We then consider the implications of student experience for the analysis of equity.

Background and Rationale

The persistent problem of achievement gaps between under- and well-served groups in the U.S. has defied simple solutions for decades. Billions of dollars and years of effort have done little to improve the dismal and, indeed, worsening, picture. In 1996, the U.S. National Research Center’s TIMSS Project (NRC, 1999a) reported that a major barrier to improving science education included the quality of U.S. science curriculum overall. They argued that it was unfocused and fragmented, and the textbooks and curriculum materials used came in for special criticism. Even when improved materials are obtained, teachers have difficulty implementing them and delivering instruction consistent with educational reform goals. Several systemic reform initiatives of the 1990s emphasized the need for a more focused science curriculum and better curriculum materials for teachers to use (aligned with science standards, instructional methods, and assessment/accountability measures). U.S. science textbooks are larger and often more colorful than those of other countries, but they are sometimes less comprehensible, more repetitious, and tend to ask students to do tasks that only require low-level kinds of thinking. As Lynch and colleagues (2003) pointed out in a recent paper, “It is reasonable to assume that improved curriculum materials aligned with science education standards that encourage students to learn with understanding could accelerate the reform process.”

In the mid-1990s, Project 2061 carried out an extensive review of the science education research literature and created a list of instructional strategies that the research base suggested ought to be built into curriculum materials. The resultant Project 2061 Curriculum Analysis is arguably the most detailed and thorough curriculum evaluation process of its kind to date (Kesidou & Roseman, 2002, but see also Holliday, 2003). It relies on the research base and the rational judgment of teams of experts trained to use the process. Project 2061 developed a systematic procedure to evaluate written science and mathematics curriculum materials, geared to the teaching of national science standards and benchmarks, with indicators for each criterion to guide the ratings made about the quality of the curriculum materials.

The Project 2061 Curriculum Analysis analyzes curriculum materials to ascertain: first, if there is a focus on a specific benchmark/standard (content analysis) and second, how well twenty-two instructional criteria in seven categories are met (instructional analysis). The seven categories organizing these criteria ask
whether the curriculum units (1) convey sense of purpose; (2) address student ideas and misconceptions; (3) promote engagement with relevant phenomena; (4) promote use of scientific ideas and terminology; (5) encourage student thinking; (6) encourage assessment of progress; and (7) create a learning environment: curiosity and inquiry for all students. The assumption was that curriculum materials with high ratings according to these criteria should result in superior student outcomes on the target benchmark/standard compared to curriculum materials that would not receive a high rating.

However, these 2061 criteria were designed largely for the analysis of curriculum texts and other instructional materials, not for how the students interpreted or used the instructional materials as part of their process of classroom participation. As Erickson & Schultz (1992) observe, there is “virtually no research on how curriculum is actually experienced by children.” Moreover, there is little information on how these criteria are interpreted by diverse students. Project 2061, for example, asks if a unit “conveys a sense of purpose,” but how can we tell when a sense of purpose has been conveyed to the students enacting a unit that has been highly rated according to this criterion? In other words, what consistent, patterned, student behaviors are observable that would indicate that a curriculum unit has actually achieved this goal? Likewise, what sorts of methods would allow one to study “engagement with relevant phenomena”? What counts as evidence of “engagement” in an actual classroom setting? Even more problematic is “student thinking”: What counts as evidence of thinking? Finally, the 2061 project provides little information on how these criteria might be interpreted by diverse students. Does “student thinking” look and sound the same for all students? How about engagement with relevant phenomena? Finally, how can we organize our answers to these questions in a way that reflects a child-centered focus on the curriculum as it is experienced by its intended audience?

In summary, then: How can we devise ethnographically-oriented criteria by which we can evaluate curriculum units as they are implemented in classrooms with diverse students, rather than curriculum units on paper only? In what follows, we seek to focus on how curriculum texts are part of an ongoing system of classroom participation. We then attempt to use the results of these ethnographically-oriented criteria for interpretation of variations in outcome scores.

From Sense-Making to Text-Building

In order to understand how students experience a curriculum unit, it is important first to understand what it is that is being experienced. While the term “curriculum” generally refers to a course of study, it also refers to the instructional materials that support those learning activities. In general, those materials take a textual form.

While the move toward student-centered curriculum has familiarized educators with the idea of learning as a form of “meaning-making,” Becker points out that texts are a crucial framework by which people (not only students) “build” meaning from experience. Whether it is through telling stories, convey-
ing content or communicating intentions, students construct meaning for them-
selves from curriculum materials by building text-like models of key ideas. If cul-
tural differences consist of differences in systems of meaning, a focus on how 
students experience and make meaning out of curriculum materials can thus 
provide a central route for teachers to appreciate, understand, and work with 
student cultural diversity.

Of course the study of texts is nothing new; centuries of sophisticated scholar-
ship have been devoted to textual exegesis. But while the field of literary criticism 
has developed elaborate approaches for interpreting written materials, these 
frameworks are often difficult to implement in the complex, active and richly 
oral environments of everyday life. Becker (1979) proposes that we view such 
activities as “text building”—a dynamic, on-going process of using linguistic and 
social forms to create meanings. The four dimensions he urges us to consider 
are:

1. **The relation of texts to the outside world.** These are what the text constructs as 
a “referent” or “content” of the materials. For example, a curriculum unit 
might be devoted to constructing for students an image of atoms and mol-
ceules as the referent or content of the materials.

2. **The relation of the text to the intention and goals of its author.** In a curriculum 
unit, of course, these are pedagogical in nature. For example, in one curricu-
ulum unit, the goal might be to encourage children to learn by memorizing 
the text and testing them later on their knowledge of the content; another 
curriculum unit, on the other hand, might set for itself the goal of encourag-
ing children to learn by engaging in and doing relevant activities.

3. **The relation of the parts of the text to one another.** A curriculum unit might 
be understood as a kind of narrative in that its lessons are organized in a 
particular way in order to structure students’ experiences with the concepts 
it is trying to convey. Students’ experiences are also structured on a daily 
basis as a unit is implemented. Ethnographically, one can note that some 
units have students devote considerable time to preparing for and perform-
ing group lab activities, while others provide students more time to reflect 
on experiments. The integration of these various types of classroom activ-
ities with one another—its coherence—varies from one curriculum unit to 
the next.

4. **The relation of the text to other relevant texts outside of it.** Students experience 
a given text partly in relation to their expectations about how similar texts 
convey meaning, and according to their own preferences about how to rep-
resent the text to themselves and to others. Thus some students expect to 
write a lot during a curriculum unit, others expect to talk and build verbal 
representations of the curriculum ideas, while still others expect to build 
haptic, tactile representations of the text.

Curriculum units as they are implemented and experienced by actual children 
may thus be thought of as part of a process of “text-building.” Somewhat like a 
script for a play, curriculum units are a set of instructions for action that are
interpreted in various ways by individual students and teachers much like actors who each “build” an interpretation of a script in individual ways through various reading, speaking, and acting strategies. The job for the researcher, then, is to interpret the dimensions by which the students make sense of the curriculum—the text itself, the roles intended for them, the phenomena under investigation, and their teacher’s actions.

**Video Ethnography**

In order to apply this model to the classroom data, we conceive of the “text-building” process in ethnographic terms. By “ethnography” we mean a detailed description of the communicative practices of a group, and of the culturally-defined situations in which relevant distinctions are made in that system (Conklin, 1962). Drawing broadly on a sociohistorical framework of analysis, we examine learning as a form of participation in such culturally-defined activity systems.

To carry out the study that we report on in this chapter, students were videotaped throughout the implementation of a highly-rated science curriculum unit, *CTA*. This process resulted in fifty-eight hours of recordings. The videotapes were digitized, transcribed, and analyzed using advanced database software. The resulting keyword-searchable corpus includes approximately 2500 pages of videolinked student discourse, which are coded for class period segments, clarification, object manipulation, scientific term use, and literacy practices.

**The Curriculum Unit**

The curriculum unit that is examined in this chapter was chosen because it was highly rated by Project 2061, and involves active learning and hands-on manipulation of relevant phenomena. While not explicitly designed for a diverse student body, the theoretical framework guiding the developers appears to have been one that recognizes the social and historical context of learning. The unit is described here briefly.

*CTA*

This unit is the product of researchers from the School of Education at Michigan State University led by Theron Blakeslee (1993). *CTA* is designed for students in grades 8 to 10, and in this study *CTA* was implemented in an 8th-grade classroom.

The benchmark concept toward which *CTA* is aimed is the conservation of matter. By first observing, and then weighing, four different reactions under different conditions, students are to realize that (1) within a closed environment, mass (operationalized as weight in this unit) is conserved, and (2) that the rearrangement of atoms and molecules can help one to understand the conservation of matter.
The four reactions that are central to this unit—burning, rusting, the decomposition of water, and the reaction of baking soda and vinegar—are revisited in each of the unit’s four clusters of lessons. In Cluster One, “Describing Chemical Reactions,” students are asked to observe “common, everyday household substances” in various mixtures, to describe the physical and chemical changes they see occurring, and to observe when new substances are formed. Cluster Two instructs students to compare the mass of substances during physical and chemical reactions (by weighing mixtures before and after) in order that they will realize that matter—even invisible matter like gases—is conserved. Students are introduced to atoms and molecules in Cluster Three, and are asked to construct explanations of the weight changes they observed in the four reactions in terms of the rearrangement of atoms and molecules. A fourth cluster, focused on the energy changes in these reactions, was not implemented in this study.

Constructing the “Content” of the Curriculum

The specific content focus or referent of CTA is the particulate nature of matter and its conservation. This “content” item is seen as being real (unlike, say, Huck Finn in a literature class) and “natural” (having an external reality independent of the text of the curriculum). This content is then “conveyed” to the student via various means—experiments, illustrative examples, visual aids, workbook questions, etc. (see Project 2061 #1).

But curriculum units may establish the external reality of their ideas in different ways. For CTA, one way that the “reality” of the conservation of matter is conveyed is through the transformation of a balloon in its appearance and shape. The balloon thus becomes an icon resembling the process the authors wish to illustrate.

In the first cluster or section of CTA, students observe four reactions, like the one described above, that are meant to iconically represent the conservation of matter: a balloon is sucked into a flask, an equal arm balance dips dramatically as the baking soda and vinegar bubble away furiously in a flask atop the balance, and so on. The Law of Conservation of Matter is thus “seen” (in part) by means of these kinds of experiments. Thus, in the first section of CTA, the conservation of matter is made visible, so to speak, through these dramatic, iconic experiments which students appreciate without pen or calculator or graph paper in hand.

In the second section of CTA, however, the concept of the conservation of matter is made transparent by means of numerical inscriptions: observed “weight changes” are to serve as evidence of the conservation of matter. Students perform a mathematical calculation (subtraction) between what the teacher calls “the before weight” and “the after weight” of the mixture, and it is this inscription, “the weight change,” that students are to understand as “evidence” of the Law of Conservation of Matter. The instructional materials and the teacher scaffold this analytic move, albeit in subtle ways. For example, regularly-occurring rhetorical and linguistic forms assist students in appreciating that “the before weight” and “the after weight” are in a relationship, and that a relationship
between the two numbers is compelling evidence of the conservation of matter. We have argued elsewhere that unusual nominalizations, syntactic structures, and pragmatic forms systematically appear at critical junctures in the text of CTA that function to emphasize for students that one set of inscriptions (the numbers written on their worksheets representing “the weight change”) is what allows students to “see” the conservation of matter. In CTA, students observe several physical and chemical changes without actually weighing anything at first; students are guided through this process over the course of the unit, from the structure of the lessons (discussed in detail below) to the linguistic and rhetorical features of the text.

One can hypothesize that the way that the target idea is constructed is due at least in part to the nature of the curriculum content (or “referent” in our terms). The experiments that the students conduct in CTA are not familiar to the students—the bubbling and fizzing and test tubes involved are in fact prototypically “scientific” in nature and thus do not need to be defamiliarized in the same way that they might in a different unit, whose lab activities are more pedestrian, or at least less marked as scientific.

*Constructing the Intentions or Goals of the Curriculum*

Another way by which the purpose of the lesson (Project 2061 #1) is conveyed is by interpreting the intentions of the authors of the curriculum units. In CTA, the purpose of the curriculum unit and, indeed, the individual lessons, is to initiate students into the practice of scientific activity through hands-on experience and group work. CTA piques students’ interest in the benchmark concept by having them puzzle over four unusual experiments in the first cluster of lessons and, in the second cluster, collect data on these experiments, and puzzle over inscriptions (the weight changes) rather than the actual phenomena.

Another way of thinking about what this unit intends for the students is in terms of models of participation and apprenticeship. The developer of CTA, Theron Blakeslee, wants to apprentice students into the world of science by creating opportunities for vivid experiences in which they participate in groups, gather around the apparatus, perform experiments, and discuss the results. While students debate the significance of these experiences, they move from peripheral to legitimate participation (Lave & Wenger, 1991).

*Coherence: Narrative Flow*

As Becker (1979) points out, another way in which to build meaning through text is through the organization of the parts in relation to one another. In classrooms, this manifests itself in two ways: (1) the sequence of activities across the eight-week unit; and (2) the sequence of activities in any given lesson. As a way of talking about the different kinds of ways in which the curriculum units build stories about the benchmark concepts for children, we call the first “unit flow” and the second “lesson flow.”
**Unit Flow**

In *CTA*, the concept of the conservation of matter is only introduced midway through the curriculum unit. A series of quite different experiences are introduced that all come together to explain a single law of the conservation of matter.

In *CTA*, roughly halfway through the unit, the students are introduced to the Law of Conservation of Matter as a “fundamental law of nature,” as well as being introduced to the Periodic Table and the concept of atoms and molecules as authoritative facts. (The authority of these concepts is not only predicated with sentences such as, “Scientists have found,” etc. but also graphically marked with capitalization, bold fonts, etc.). Students are basically told that this is what explains the experiments they have performed. The third cluster of the unit requires students to build molecular models of those same four reactions to drive home the molecular explanation of their experimental results. Thus, the narrative coherence of *CTA* hinges on the introduction of an explanation for students’ experiments. Students in *CTA* are explicitly told that their observed weight changes are evidence for the law of conservation of matter.

**Lesson Flow**

Understanding the ways in which this curriculum unit makes use of class time is crucial in constructing a picture of how *CTA* functions within the classroom. To examine this ethnographically, and its implications for students’ experience of curriculum coherence, we have focused on class period segments, or the types of activities that the students engaged in at various moments during the course of a school day.

**Classroom Period Segments (CPS)**

These categories were based on distinctions that appeared relevant to students’ and the teacher’s participation in activities. Shifts between classroom period segments are often indicated by “contextualization cues,” such as visual cues from the teacher (e.g., turning lights on or off), students’ repositioning at the table in terms of visual and bodily orientation, and changes in students’ communication patterns (e.g., if they’re talking, to whom, and about what). Bounded by these cues, these segments of activity can last for only a minute or two, or can endure for almost the entire class period. The six class period segments we coded for are: Warm-up, Presentation, Exploration (Group, Class, and Individual), Reflection, Closure, and Transition. The distinctions between these types of classroom activity are detailed in Table 11.2.

The classroom period segments with the highest frequency are Group Exploration, Presentation, and Reflection, occurring in every single lesson of the curriculum unit. Individual Exploration, though it peaks during lesson 16 (Atoms In Equals Atoms Out), makes up a very small percentage of the total segments coded for CPS. Group Exploration and Reflection, on the other hand, occur
### Table 11.2: Types of classroom activity

<table>
<thead>
<tr>
<th>CPS</th>
<th>Characteristics</th>
<th>Contextualization cues</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-up</td>
<td>• Designed to get students thinking or review material presented the previous day</td>
<td>• Indicated by verbal cues like “For your warm-up today, you will”</td>
<td>• Fifteen to twenty minutes</td>
</tr>
<tr>
<td></td>
<td>• Students oriented toward the front of the room</td>
<td>• Students oriented toward the front of the room</td>
<td></td>
</tr>
<tr>
<td>Presentation</td>
<td>• Teachers familiarize students with what they will be doing, give lesson objectives, and/or introduce a new concept or idea</td>
<td>• Indicated by verbal cues like “Today, you are/we are…”</td>
<td>• Usually five to ten minutes</td>
</tr>
<tr>
<td></td>
<td>• Procedural Presentation: what students will be doing, what materials they need, and how they will conduct the exploration</td>
<td>• Students oriented toward the front of the room</td>
<td>• May be longer if it involves a demonstration or lecture/explanation</td>
</tr>
<tr>
<td></td>
<td>• Conceptual Presentation: a demonstration/lecture, or students answer introductory questions</td>
<td>• Discourse is focused on the future</td>
<td></td>
</tr>
<tr>
<td>Exploration</td>
<td>• An experiment, lab, or written activity that provides experiences of the main concepts</td>
<td>• Indicated by verbal cues like “Once you get your materials…”</td>
<td>• May be as short as ten minutes or last the entire class period</td>
</tr>
<tr>
<td></td>
<td>• Individual Exploration: students work alone</td>
<td>• Indicated by movement of students to gather materials or go to lab stations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Group Exploration: students work in groups of two or more</td>
<td>• Students oriented toward the center of their tables or to their papers where they are recording the activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Classroom Exploration: teacher leads the class</td>
<td>• Students oriented toward the front of the classroom or toward the table</td>
<td></td>
</tr>
<tr>
<td>Reflection</td>
<td>• Students reflect on an activity (Exploration) they've completed</td>
<td>• Indicated by verbal cues like “Now that you’ve completed the activity, I’d like you to answer…”</td>
<td>• Usually ten to twenty minutes but can last the entire class period</td>
</tr>
<tr>
<td></td>
<td>• Can occur through teacher-led discussion, but is often a written activity completed individually, in pairs, or in groups</td>
<td>• Students oriented toward the front of the classroom or toward the table</td>
<td></td>
</tr>
<tr>
<td>Closure</td>
<td>• A comprehensive statement or activity that summarizes the day’s activities and/or relates them to a key concept</td>
<td>• Indicated by verbal cues like “So” or “Okay”</td>
<td>• Two to five minutes</td>
</tr>
<tr>
<td></td>
<td>• Sometimes done in the form of exit cards or tickets to leave</td>
<td>• Students oriented toward the front of the room, or the table if they're doing a written closure</td>
<td></td>
</tr>
<tr>
<td>Transition</td>
<td>• Movement between activities, natural “downtime,” or when students are waiting to leave</td>
<td>• No central focus of student attention</td>
<td>• A few seconds to ten minutes</td>
</tr>
</tbody>
</table>
frequently and in large chunks. Reflection, in particular, becomes more pronounced toward the end of the unit. Classroom Exploration occurs more frequently at the beginning of CTA and diminishes toward the end, which may mirror a trend of greater student autonomy over the course of the unit. Closure peaks in the middle of CTA during lessons 6 and 8, which address whether weight changes in chemical reactions and whether gases have weight, respectively. Finally, Warm-up does not appear to be a constant feature of the classroom activity sequence, but does occur periodically during CTA. The graph (Figure 11.2) below represents each classroom period segment as a percent of total coded segments for each lesson of the unit.

**Intertextuality**

As Becker points out, the process of “text building” proceeds according to the expectations that an actor (e.g., a student) has about what a text should be. That is, students build textual representations of their experience by constructing representations of their own that model, or in some way mirror, the ideas being conveyed in the curriculum unit text. In our study, we observe how the students interpret the curriculum by linking it to other sense-making strategies of
representation such as (1) use of the scientific register and scientific terms; (2) haptic representation and object manipulation; and (3) literacy practices. Unlike the first three aspects of text-building (i.e., conveying of content, goals, and narrative flow), this aspect of students’ curriculum experience belongs to an informal kind of meaning-making that is often harder to identify, but nonetheless crucial for understanding how the curriculum functions.

**Scientific Register: “Weight”**

AAAS Project 2061 criterion #4 states that to be effective, curriculum units should “promote use of scientific ideas and terminology.” While science educators have long recognized the distinctiveness of a scientific register, ways of dealing with this have differed. Some sought to minimize the distinctiveness of the scientific way of talking by avoiding specialized jargon and terminology; others sought to force students to memorize terms as a way of providing students with access to key concepts. At the forefront of many of the discussions regarding how scientific terminology is taught in the classroom is the issue of diversity. In the U.S., students have a large range of experience generally with the English language—from having only just arrived in the U.S., never having spoken English before, to growing up in a bilingual household, to being raised solely speaking English. Furthermore, students have varied degrees of prior experience with the scientific register, depending on their parents’ occupations, or on what books they have read as children. Although students may not be aware of all of these distinctions when they arrive in their science classroom, this prior experience can significantly impact students’ experience with the scientific register when they encounter it in class. In our study, we aim to understand more about how students use scientific terminology as part of their sense-making practices in the classroom. We do this by searching the transcripts for evidence of the use of a scientific register appropriate to the curriculum.

Although there seems to be some consensus that teaching science to children involves familiarizing them with how to “talk science,” there remains a great divide between the linguistically-oriented researchers who focus on the details of linguistic form in written texts, and the more socially- and pedagogically-oriented scholars who examine verbal interaction in classrooms. There are relatively few scholars who examine the relation between features of linguistic form and how these are used as functional resources by children in classroom learning environments.

There are several reasons for paying close attention to form-function relations. One is methodological. In order to code videotapes (or direct ethnographic observations for that matter) reliably and in a valid manner, a broadly linguistic and ethnographic approach is useful as an analytical framework. When identifying and classifying student activities, unless the categories used correspond to those being used by the students themselves, the categories are unlikely to prove useful in the long term for research purposes. While there are important “limits of awareness” (Silverstein, 1979) among “native” users, the syntactic, semantic, and pragmatic forms of language in use can nonetheless provide reliable and valid categories for analysis.
Scientific Term Use in CTA

After dividing all the videos into Class Period Segments, we focused on the moments of Group Exploration (GE), defined as periods of time when students are exploring the benchmark concepts in the unit in a small group, and this usually involves the performance of hands-on lab activities. As noted above, CTA devoted significant amounts of time to group exploration.

We selected the scientific terms for consideration by eliciting them from teachers through a written survey. They responded to the question “What are the key terms in the unit?” We used these terms as the basis for a key word search through the transcripts.

After coding for a set of terms suggested by the teachers, we found the patterns depicted in Figure 11.3.

In CTA, students used the appropriate scientific terms with relative frequency, often as part of a strategy of building an argument and making sense of classroom activities.

Example of Scientific Term Use: Nominalization

In CTA, the key benchmark ideas are accessed partially through nominalization. By “nominalization” we mean the grammatical process by which verbs or adjectives are transformed into nouns. In general, the trend over the course of the curriculum was an increase in the percent of student term use that was nouns. In other words, students were using more nouns as terms toward the end of the curriculum, rather than verbs, adjectives, or adverbs.

In the first few lessons, students were describing substances and reactions, which prompted more adjectival term use; they were also saying what was
happening in the various reactions they were being shown, triggering more verbal term use. By the end of the curriculum, students were talking more about the objects, processes, and concepts behind what they’ve observed and described—objects like “atoms,” “molecules,” “oxygen,” “hydrogen”; processes like “a weight change”; and concepts such as “the conservation of matter.” This objectification, or the turning of processes into object-like entities, signals that students have transformed their scientific talk from descriptions and observations into object-like nominal knowledge—a hallmark of scientific language (Halliday & Martin, 1993).

There is one particular nominalization that plays a critical role in the curriculum’s narrative structure. In CTA, in order to grasp the central idea of conservation of matter, it is essential to learn to use the verb to weigh not only as the nominal “weight,” but as the subject of a verb e.g., “the weight changed” or “the weight remained the same.” Mastering this relatively unusual locution (unusual in probabilistic terms) is nonetheless central to effective participation in the curriculum and thus “attainment” of the concept. In the example from our Introduction, both Sean and Philip use “weight” in describing the procedures for the lab they are performing. In both cases, they are transforming another statement to include the nominal form of “weight.” In the first case, Sean starts to say, “Okay but weigh it all first” and then stops himself, and says, “We have to do the before weight.” There is no procedural difference between “weighing it first” and “doing the before weight,” but Sean decides mid-sentence to restate the instruction, perhaps invoking more authority by using a nominalized scientific term. In the second use of “weight” in the above example, Philip reconstructs Sean’s
sentence, but with the addition of the nominal “weight.” He takes “lid” from Sean’s suggestion about what to do next and creates a novel nominal construction similar to the use of “before weight” and “after weight”: the “lid weight.” In both cases, the students’ rephrasing of previous utterances calls up a nominal compound using the nominalized form “weight.”

Insofar as these novel, nominal constructions serve to decontextualize and desubjectivize students’ lab experiences, this linguistic detail is critical to how the unit is designed to help students understand the benchmark concept. It brings the focus onto the data that they are to collect and should transparently demonstrate the conservation of matter. In other words, there was a sort of “habit of mind” that this linguistic maneuver was involved in engraining. Otherwise-invisible actions of oxygen atoms and iron atoms (in rusting, for example) can be “seen” so to speak, or made transparent, at least in part, by the appropriate grammatical characterization of one’s evidence. If “the weight of a mixture” is in the grammatical subject position of a student’s utterance—“the weight increases/decreases/stays the same”—this may indicate that a student understands what counts as data, and may be that much closer to understanding what explanation that data is evidence for.

Moreover, when the children did nominalize in this way, it had consequences for their participation at the table, as again the example in the Introduction illustrates. Philip, for example, generalizes from this linguistic form at key interactional moments, especially when his special status as “table expert” is questioned. This student responds to his lab mates in the interaction by immediately nominalizing what they have just said (“a slight difference” and “lid weight”). As the science expert, this student is responsible for “data collection,” and he re-casts what they are doing at the table as the collection of things (first differences and then lid weights), and thereby re-establishes his authority.

In CTA, the focus was on observing a single event, describing and explaining its qualitative change (or lack thereof). Thus, nominalizations were provided to students as a resource for explaining the curious phenomena they were observing. For CTA, the verbal expression of nominalization was presented as integral with the process of explaining the benchmark idea.

**Haptic Representation Through Object Manipulation**

The conventional wisdom in science education is that good science curriculum units permit “direct experience of relevant phenomena” (AAAS, 1989), or “hands-on learning.” Drawing on Becker’s semiotic model, however, we argue that hands-on learning is not a form of “direct experience,” but rather a form of *haptic representation*. That is, touching things is but one way—among many—of representing and making sense of one’s experience in a science education context. Like other forms of sense-making practices, object manipulation is a way of building a representation—in this case a *haptic* or tactile representation—of a phenomenon so that it can be interpreted, and thus made sense of. Like scientific term use, sketching pictures on paper, or conversation and hands-on activities in science classrooms, are informal ways of “text-building” in Becker’s
sense because they result in the construction of sensory representations that are
in turn linked in the context of practice to the text of the curriculum unit.

A great deal of research on object manipulation in science classrooms focuses
on the number of minutes students spend in labs correlated with achievement
scores. However, few studies examine the behavior and patterns of individual
students and the implications of those patterns on student learning. In their
study of autonomous manipulative use in a mathematics classroom, Moyer and
Jones (2004) found that students’ manipulations differ from the teacher’s
intended uses. In turn, these innovative manipulations create changes in student
participation; some students spontaneously used manipulatives to tutor their
peers, whereas others controlled the objects in an effort to direct their group and
their classmates. These types of actions would not be possible without the medi-
ating object being introduced into the classroom. Taking this into consideration,
we developed a taxonomy of object manipulation types based on framing theory
to examine students’ use of the objects and how object manipulation affected
participation in labs.

The graph in Figure 11.5 provides a picture of the extent to which each child
goes in particular kinds of haptic experiences. These students appear to have
different patterns of activity related to the objects. While Philip was deeply
engaged in completing the scientific procedures as outlined by the text and
teacher, Gloria participated in procedural usage three times less than Philip.
Gloria often relied on Natalie to retrieve and return goggles for her and fre-
cently issued directives to Natalie about which goggles she wanted. Moreover,
of all the students at her table, Gloria positioned the objects away from Philip
most. Natalie participated haptically most often through retrieving and return-
ning objects. Sean’s object manipulation was by turns playful and procedural; that
is, he was as likely to play with the lab objects as to use them for the procedure.

In spite of their differences, however, it is clear that these students spent the
majority of their haptic activity in conducting scientific procedure, which is, in
general, in keeping with the curriculum’s intentions. For three of the students at
the focus table, procedure was their most frequent type of object manipulation.
As Rosebery, Warren, & Conant (1992) demonstrate, the activity structure of the
science classroom has important implications for the development of scientific
literacy. Students who are active participants in a scientific investigation are
more likely to know how to study something independently and how to build
upon their knowledge, rather than treat a text as a set of static facts. Engaging
students in active learning becomes important as scientific literacy is not merely
about memorizing facts, but about using, constructing, and reflecting on scient-
ific ideas.

In the example given at the beginning of this chapter, all three students were
actively participating in the lab procedures. However, this was not the case
during the entirety of that particular class period. At the beginning of the class,
Sean and Natalie stood watching as Philip handled the objects and completed the
procedure. After a while, Sean and Natalie’s gaze began to be directed to other
areas of the classroom. Sean laid his head down on the table and looked around
the classroom while Natalie looked down at the floor. Philip, however, intently
watched the scale and mused about why the substance was taking so long to dissolve. The students’ interest in the lab seemed directly related to the amount of time they spent touching the objects. Prior to the interaction we presented, the teacher had stopped at this table and specifically directed Natalie to measure a substance for the next part of the lab. Sean, too, became more actively involved when Natalie began to participate in the lab. The teacher’s intervention and assignment of tasks had an immediate impact on the students’ engagement in the lab activity.

Recent research comparing visual and haptic modalities’ effect on learning has shown that there are differences in what an individual learns through a particular mode. For example, students given a tactile task will tend to make judgments related to the texture, whereas the visual mode is often better for making spatial judgments. However, when comparing effectiveness, the combination of modes is superior to visual or haptic modes alone. Thus, it seems that students who merely watch labs may not develop as rich a judgment of the phenomena as those who engage in active touch and manipulation of the materials. If this is true, it seems especially important to pay attention to the ways in which students participate in labs and the implications that social and behavioral patterns have on lab group dynamics. While conventional wisdom may dictate that “hands-on” does not necessarily mean “minds-on”, haptic research shows that deliberate touch has crucial implications on what students learn.

With this particular group, the social dynamics among the students greatly influence the lab procedures. Philip, somewhat of a social outcast in this class, always tries to be heavily involved in conducting the lab procedures. At the beginning of this unit, if he was not given a turn to touch an object, he commented that it was “not fair.” Over the course of time, the students at this table expected that Philip would want to be in charge of the equipment—as can be seen in the object manipulation chart. Philip’s object manipulation is far greater than any other student in his group. Philip’s desire to engage in lab procedures is so great that he and another student (Gloria) got into a heated argument one day.

![Object Manipulation Types by Student.](image-url)

*Figure 11.5 Object Manipulation Types by Student.*
over the use of lab equipment, which led to Gloria’s refusal to work cooperatively with Philip.

Evidence of these social dynamics is found in the discourse surrounding the procedural object manipulation in the example at the beginning of this chapter. At first, Natalie and Sean looked on while Philip completed the first part of the lab procedure, offering little in the way of suggestions. When they began to participate in conducting the lab procedures, they looked to Philip for confirmation of what they were supposed to do. In line 1, Sean states what procedure he is going to do but then adds a tag question to be certain that his group members agree (S: *Okay but weigh it all first- we have to do the before weight, so I’ll- pour this in now, right?). Philip responds affirmatively. Then Natalie offers a suggestion of writing the weight they had originally recorded for the first step. Sean answers her twice, but each time Philip repeats what Sean says almost exactly, suggesting that Sean’s opinion is not enough and that his own is more authoritative. While all students negotiate the procedural aspects of the lab, it is clear in the discursive moves of this group that Philip is attempting to lead the group. At another table on the same day, this type of procedural negotiation did not take place among the students; rather, one student took control of the lab procedures by issuing directives to his lab mates. Thus, it is not uncommon for one student at the table to take an authoritative stance among his or her peers.

Hands-on lab work has a number of benefits for students ranging from increasing students’ sense of agency (Katz, 1989), development of scientific literacy (Rosebery et al., 1992), and developing more holistic haptic representations of the materials and phenomena they are working with. Since these benefits are a result of active touch, it seems important to insure that all students have access. Furthermore, because access to the objects is directly affected by social and behavioral patterns in the lab groups, it seems especially important to pay attention to and understand the diverse ways in which students use objects in the classroom.

**Literacy Practices**

Scientific literacy is a major goal of the 2061 project but it is rarely examined in its social context of use in actual classrooms. In this study, drawing on the work of Heath (1983), Street (1995), and others, we analyze literacy as not only a skill, but also as a form of practice. Therefore, we ask not merely what the students are reading and writing but how they read and write, with whom, when, and in what contexts. In other words, how does this curriculum unit orient children toward graphic information? We examine the video data for when and how the students interact with print, by writing and by reading.

In our study, we coded as a “writing” event whenever any child at the focus table had a pen in hand, in motion, while in contact with paper. Early efforts are underway to develop a taxonomic scheme that captures generalizations about the different kinds of writing that students engage in during the implementation of the unit. The data will thus be sub-coded for, inter alia, note-taking, recording data, writing involved in the performance of mathematical operations (averag-
ing, graphing, etc.), and answering worksheet questions. We also are coding for
social forms of writing, involving note-passing, and doodling, for example,
which appear to play an important role in the ever-shifting and always-
important participation structure at the tables, which affects the task structures
assigned and assumed by students as they perform laboratory procedures.

By not restricting our attention to only those acts of writing that end up being
evaluated by the teacher, we hope to trace the evolution and development of stu-
dents’ reasoning about written answers. In the above example, the students first
write down the number 116.4, but as the mixture continues to lose weight, and
the scale reads 116.3, there is discussion about whether or not to write down
“point four” or “point three.” In fact, Philip, Natalie and Sean were unsure about
what to write on their worksheets, as the mixture ought to have weighed
116.4. Thus in our analysis, we note which students wrote down 116.4, at what point,
which students cross that number out or erase it, and then which students write
116.3—in all cases attending simultaneously to the discussion going on around
the inscription of this knowledge—what number, in this case, is going to count
as the evidence about which to reason. In this class, generally, and in this lab, in
particular, Natalie seems concerned about “what to write down.” Figuring out an
answer to this question means, in this case, reconciling the authority of the
instrument in front of her that reads 116.3, with the teacher’s directive to ignore
the “point one difference” in the weight loss as it is “insignificant.”

This part of our coding project thus allows us to describe a sort of natural
history of an inscription. In Laboratory Life, Latour & Woolgar (1986) watch sci-
entists working and writing in their laboratories, tracing the evolution of the
many inscriptions bandied about in a working laboratory to find out which end
up in a published research article and which do not. Their ethnographic research
indicates that the fate of an inscription depends on many things, including dis-
cussions among the researchers in the lab, and shared assumptions about the
methodology in use—what is merely an outlier and need not be reported, for
example, and what is a “pattern” or “trend” in the data that must be included in
a draft of a paper and explained. By attending closely to students’ literacy prac-
tices, we can see that there are many parallels to Latour & Woolgar’s description
of a working laboratory, as students here are apprenticed into the cultural
assumptions about what “counts” as evidence to be explained, and what can
safely be discounted (e.g., a “point one difference”). These are critical distinc-
tions for students whose “job” it is to write things down for evaluation. In other
words, what number should be inscribed onto the all-important, graded work-
sheet? Tracing students’ literacy practices, and connecting them to a cultural
understanding of scientific practice as we do, thus offers us a unique view of stu-
dents’ apprenticeship to the nature of science, their reasoning, and their develop-
ment of conceptual understanding.

Indeed, as we conceive of learning in terms of apprenticeship and increasingly
central participation, coding for student writing seems especially important as
the episodes of writing leave definite impressions on the resulting participation
structure for the lab tables. As already noted above, of the four students at the
focus table, Natalie seems most concerned with “what to write own,” and thus
directs the attentional resources of the table to this task at various junctures in the labs. The decision of students to read out loud from the text is also critical to the development of participation frameworks important to understanding how a unit functions from the perspective of the students. We note which pieces of the text are read out loud, and by whom, as well as the conversational sequence of those moves. How do these various literacy practices, in other words, affect the participation of the students? Indeed the goal is to see if one can determine different participatory profiles for each of the students at the focus table as measured in terms of their literacy practices.

Coding for literacy events in this way allows us to begin to answer questions about the nature of the curriculum unit that would seem important to understanding how it functions for diverse learners. For example, to what extent are the curriculum materials something to which information must be added (through acts of writing), or is it a source of information, from which students read to each other? Preliminary analyses support a conclusion that, in CTA, the worksheets function more as sources of information for solving problems. The text functioned as an aid to participation in group problem solving, rather than summoning them to turn away from the group toward silent reflection. Students were responsible to the text, of course, in writing answers to questions about the labs, but these questions often appeared in the text, in situ, rather than in a separate section; that is, as the students performed the lab procedures, they were answering questions about them simultaneously. This structure seemed to facilitate students’ working and reasoning together as a group.

In Figure 11.6, the graph depicts the frequencies of acts of writing during Group Exploration, the same class period segment covered in the object manipulation and scientific term use figures above. It is clear that there is an inverse relationship between writing and object manipulation. Natalie writes the most but handles objects the least and Philip handles objects the most but writes the least. In Figure 11.7, it is clear that Natalie and Gloria are not only interested in using

![Figure 11.6](image-url)
print to *record* information, but often use it as a source of information. The graph shows that Natalie and Gloria read aloud from the text far more than Philip or Sean. Thus, even if they did not participate in the lab experiment by creating haptic representations of their experiences, they did so by creating graphic representations.

**Discussion**

Lee and Fradd (1998) point out that the effect of curricular interventions on diverse populations is very poorly understood: “little information is available on [science curriculum] effectiveness in terms of what works and why.” This is particularly true when it comes to the analysis of diverse populations: very few effectiveness studies disaggregate the data in terms of ethnicity, gender, and race. While we have presented outcome scores as one picture of what works, what was missing from that interpretation was an analysis of how the curriculum unit was experienced by the children themselves.

“Diversity” is not a word the children themselves often use; rather, it is a word used in institutions—government, education, business—in the context of management questions. How do we cope with it? What shall we do about it? In order to connect the concerns with diversity at an institutional level to the concerns of actual students, it is important to link concepts of diversity to ideas and issues that matter to the target population. One way to do this, we have suggested, is to focus on the varieties in the students’ personal experience as they struggle to make sense of their science experience. Viewed from an institutional perspective, the lab table consisting of Sean, Philip, Natalie and Gloria would likely be considered “diverse” in demographic terms. In a broad sense, the diversity of their table resembles the diversity found at other tables in the classroom, and indeed...
in the school system as a whole. But while we are not claiming that our findings are statistically representative (e.g., we do not claim that Philip can stand for all African-Americans), we wish to observe that even if they were, it would not tell the whole story. What would be missing is how to relate the demographic diversity to the subjective experiences of the students in the classroom.

Rather than comparing the students in terms that would sound strange and formal to them (e.g., demographic categories), we have sought a common framework that is closer to their experience. Since students in science classes typically share a common exposure to a curriculum unit; variations among their experiences can be the basis of comparison. Rather than relying on interviews or self-reports to access their experiences, we examine how they use language and other representations to interpret and “build” the curriculum as a meaningful “text.” To achieve and experience “science literacy” students must become competent “text-builders” of scientific meanings.

Drawing on Becker’s model of “text-building,” we examined the ways in which curriculum units provide (1) “content,” (2) “goals,” (3) “narrative,” and (4) “sense-making practices.” The variations in text-building practices, in turn, provide an interpretive framework (i.e., not a causal or predictive explanation) for the patterns of diversity in the outcome scores. In analyzing how CTA builds the content of the Law of the Conservation of Matter, we are primarily interested in the text-building processes that the ideas provoke in actual classrooms; that is, we are interested in the ways in which the curriculum unit requires students to construct and make manifest the content of the curriculum as an experienceable idea. In this case, the curriculum unit employs semiotic media to convey the ideas to students.

We show that CTA uses iconic means of communication to convey the benchmark ideas. That is, the main content idea of conservation of matter is conveyed by vivid visual transformations (collapsing balloons, rusting steel wool, foaming test tubes) that resemble the idea to be conveyed (e.g., the change in the color of the steel wool in a closed flask simulates the idea of the change of matter in a closed environment).

In reading the worksheets and interpreting the directions, the students construct images of what the goals of the curriculum unit are. In CTA, when told to act like scientists, students readily donned goggles, and used beakers, flasks, and other items that seemed consistent with that role. Students interpreted the goal as one of participation in problem solving; the distribution and allocation of roles for that participation process became an important concern for them.

The overall narrative structure of the unit and of the individual lessons was organized in ways that reflect the curriculum unit’s goals. CTA provided time for reflection, closure and debate about their conclusions. The students’ own sense-making practices are articulated here as well. While students in CTA were given relatively few nominalizations in the textbooks, they invented and used many of their own to describe their experiences: a hallmark of “talking science.” Indeed, students in CTA increased their use of scientific nominals over time. In addition, students in CTA often read aloud from the textbook as a way of solving problems. In CTA, students also had hands-on experiences, but the distribution of those experiences was more uneven.
Conclusions

Much has been made, in recent literature, about the value, for learning, of small group activity. Teachers are encouraged to have differentiated ability groupings and to provide all students in their classrooms with challenging and motivating opportunities to learn. In this chapter, we have shown that shifting the focus on classroom learners away from a broad brush characterization of “the black kids,” “girls,” “Latinos,” etc. and refocusing with an emphasis on the transactions that take place between students’ personal experiences and their classroom science learning can yield fascinating results. We have attempted to provide a rich characterization of the ways that children use talk, touch, and writing to derive and build meaning in science. Our aim was to both expand the ways teachers and classroom researchers think about what children bring to science learning, and to show how curricular materials can be used to create wonderful meaning-making contexts for students.

There are many implications to be drawn from the examples of Phillip, Sean, and Natalie and their interaction with the reform science curricular materials. First, Phillip had a strong desire to engage with the curricular lab and other materials. We suggest that the design of the materials, a design that allowed students early and regular access to the benchmark lessons of the unit, encouraged this motivation to manipulate the materials and to make meaning in science. Second, Natalie and Sean found roles in their interactions with the curricular materials, and with Phillip, that allowed them to carry out the work of science, and interpret and debate the meaning of science outcomes. Third, a close examination of how students make meaning, using science materials and using their multifaceted interactions with each other, can provide teachers with a view into what and how and through what mechanisms (e.g., writing, discussing and debating, and touching/manipulating) students come to know science. Viewing students through this type of lens can potentially enhance instruction, including small group interactions around science learning, and provide teachers with a broad array of means for naturalistic assessment of students’ knowledge in the science classroom setting.

Here we aimed to cast a bright light on the organization of student experience during a science activity. We have proposed specific ethnographic and linguistic dimensions for interpreting students’ own multimodal sense-making practices (Kress & Van Leeuwen, 2001). It is our hope that a principal outcome of this work will be to provoke increased examinations of, and discussions about, how students can and do experience curricular activities and how their various interactions with and within those activities serve to shape learning.

The approach outlined here creates an interpretive framework within which to understand the outcome data. At a time when educational research is increasingly focused on quantitative results (i.e., “outcome data”), it is especially important to observe that even when the outcome data are disaggregated in a way that reflects cultural and class differences, they still do not speak for themselves, and must be contextualized. Although educators know that the full story is not being told by the numbers, they are often at a loss to provide systematic evidence that provides a fuller picture.
The context proposed here for interpreting “what works” focuses on the nature of student experience of curriculum as text—both oral and written. This multimodal approach to both “talking science” and “writing science” shows how the curriculum functions in actual classrooms. The evaluative framework proposed for examining curriculum implementation in its communicative context permits us to take account of the different content, goals, coherence strategies, and forms of representation by which curriculum units are enacted in diverse classrooms. At the same time, it also allows for the isolation of specific factors that may be related to outcome scores. The “success” of CTA in raising outcome scores for all students may be linked to the ways in which it permitted students immediate access to the benchmark concept through multiple channels of representation—visual, verbal, written, and haptic.

Targeting Enduring Understandings
1. What are the connections you see between the discussion in the Kuipers, Brendel Viechnicki, Massoud & Wright chapter and the four elements of culturally-responsive instruction, as described by Villegas and Lucas?
2. How would you describe the “work” that language is doing in this multicultural context?

Deepening the Reflection
1. This chapter showed that students are diverse in their patterns of participation. What do you think is the relationship between diversity as participation and the more traditional definition of diversity as demographics (e.g., race, gender, ethnicity, etc.)? What are some of the kinds of diversity that you have noticed in students’ ways of participating with science curriculum materials? How may those ways of participating interact or not with demographic diversity?
2. Consider in what ways a student’s experience with curriculum materials is different from a teacher’s experience with the same materials. What might account for the similarities or differences in experience? How would this affect teaching and learning?
3. What strategies or tools could you as a future science teacher use to better understand how your students are interacting with the curriculum materials?

Encouraging Engagement
1. Identify a curriculum unit that you think has many of the same characteristics as CTA. To what extent do you think the unit would appeal to diverse teachers and students (both in terms of participation and demographic diversity)? To what extent does the unit provide multiple routes of access to the benchmark idea?
2. Observe science instruction in a classroom with culturally-
linguistically-diverse learners on a day in which students will be engaged in hands-on inquiry, like that described in this chapter. Using one or more of the analytic tools introduced in the chapter, account for students’ participation in their science learning and their interaction with each other in the inquiry activity.

References


