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Orchestrating the Multiple Voices and Inscriptions of a Mathematics Classroom

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The purpose of this article is to explore how inscriptions are used to create argumentative positions in the 2 classroom episodes, *Batteries* and *AIDS*. This activity is similar to a prominent practice of scientific communities: the use of inscriptions to advance knowledge claims. We begin by discussing the meaning and function of inscriptions in scientific communities and then apply some notions from the history and sociology of science to our analyses of the case study data in the 2 episodes. In addition, we address some of the challenges for teachers in incorporating scientific practices into their classroom activities. Among these challenges is the need to alter the nature of the problems and inscriptions used as well as change classroom discourse structures. In our analyses of the 2 episodes, we found that the classroom activities resembled those of scientific communities in several ways: Real-world, dilemma-driven problems were presented; students evaluated the inscriptions offered in terms of their adequacy for advancing particular knowledge claims; and the teachers helped their students reflect on, clarify, expand, evaluate, oppose, or integrate each other's explanations into their argumentative positions. We also found that the teachers legitimated student contributions to the discussion by revoicing their arguments. Despite the positive findings from our analyses, we were able to identify and illustrate one additional challenge for future design experiments: How do we orchestrate the multiple voices of the classroom in an equitable fashion while pursuing our instructional goals?

Educational reformers, in the past decade, have suggested that classrooms at least introduce students to some of the problem-solving activities of practicing mathematicians and scientists. Until recently, few people considered that the activities of mathematics classrooms should resemble those of scientific communities. Never-

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theless, if these two communities share nothing in common, then students will be unprepared to appreciate the value of scientific endeavors or to see themselves as becoming mathematicians or scientists. There are several reasons for this proposal, which include the need to change students' beliefs and attitudes about the nature of mathematical activity and the need to provide instructional activities that are more consistent with a constructivist orientation to learning (e.g., Carpenter, Fennema, Franke, Levi, & Empson, 1999; Cobb, Gravemeijer, Yackel, McClain, & Whitenack, 1997; Lampert, 1990).

The purpose of this article is to investigate whether the discussions of inscriptions in the two classroom episodes, *Batteries* and *AIDS*, resemble, in any way, the view of scientific practice that appears in the writings of sociologists and historians of science (Bazerman, 1988; Goodwin & Ueno, 2000; Latour, 1987, 1990). A brief summary of some relevant features of this research on scientific practices is followed by a discussion of its connection to some recent research in science and mathematics education. We then apply some key concepts to the analysis of the classroom discussions in the two instructional episodes.

INSCRIPTIONS AND ARGUMENTS IN SCIENTIFIC PRACTICE

One way to understand the practices of scientists is to focus on the historical evolution of both inscriptions and arguments within scientific communities. Bazerman (1988) proposed that the central activity of scientists is argumentation: the need to persuade others that one's ideas are valid. These arguments center on truth claims about symbolic models or inscriptions. Sharing Bazerman's perspective on scientific practice but applying it to educational research, Lehrer, Schauble, and Petrosino (2001) defined inscriptions in the following way:

> Inscriptions, a term that we use to include drawings, maps, diagrams, text, recordings from instruments, mathematical formalisms of various kinds, and even physical models, serve to preserve, compose, and make public parts of the world so that they can be subjected to argument, they can be progressively built up and elaborated upon, and their history can be captured and preserved. Inscriptions do not merely copy the world; they select and enhance aspects of it, making visible new features and relations that cannot be seen by observing the objects and events themselves. For example, a road map selects and enhances aspects such as distance relationships and scale that are not visible to an individual at "ground level," while leaving out other features that are not important to the purposes of the inscription—such as trees, power lines, and buildings. (p. 259)

Thus, inscriptions are a broad array of symbolic and material objects that serve a specific purpose in a scientific community: They represent aspects of the world, they support argumentation, and they preserve historical events. Inscriptions are a form of representation that permits public discussion, unlike mental representations, which do not (Roth & McGinn, 1998). Once an inscription is created, it can be modified (a single inscription can be made more abbreviated or more elaborated; multiple inscriptions can be combined or layered) as new ideas are developed. Because inscriptions are selective (not exact copies of the things they represent), some attributes of those things are exaggerated whereas others are deleted. Thus, any particular inscription could be said to afford or support one idea or position in an argument while constraining other ideas or positions.

An example of a famous inscription in the history of science is the double helix, which is a geometric figure and a symbolic model of a material object (DNA). When Watson and Crick began working on their double helix model, they became aware that the famous chemist, Linus Pauling, had proposed a three-chain helix (Latour, 1987; Watson, 1968). At first, they worried that his model would triumph over theirs (despite the fact that they had already tried and rejected a similar model). Then, when they examined Pauling's model in detail, they realized its fatal flaw (a lack of hydrogen atoms to keep the structure together) and quickly completed their analysis of the double helix before Pauling realized his mistake (and proposed a double helix himself). Watson and Crick worked in great haste to articulate the properties of their model because they needed to strengthen their case in anticipation of or in reaction to the objections of other powerful figures within their community. As a result, they discovered additional features of the double helix model that were consistent with well-known biochemical principles. For example, the complementary structure of the double helix afforded an explanation for gene division that allowed each strand to replicate itself (Latour, 1987; Watson, 1968). Thus, they were able to capitalize on the affordance of their inscription to enhance their argument. Although their initial work on the double helix model was heavily criticized, they eventually succeeded in convincing their scientific opponents of the plausibility of their inscription of DNA (and the implausibility of other inscriptions).

If one wants to understand the evolution of an inscription, like the double helix, one needs to appreciate its emergence within a particular scientific community at a specific time and place (Latour, 1987). Inscriptions are tools that do not have any inherent meaning apart from their context of use (Roth & McGinn, 1998). Thus, the double helix could represent a number of different symbolic or material objects. In the context of the scientific debate about the nature of DNA, the double helix form became associated with a particular set of knowledge claims that Watson and Crick were advancing.

The adequacy of an inscription depends on its intended audience. Inscriptions from highly specialized scientific journals such as *Physics Today* would not be acceptable in more popular journals such as *Scientific American* because they would be inaccessible to the general public. Roth and McGinn (1998) argued that this is true because some inscriptions represent many years of development within a particular field and are not interpretable to a broad audience outside that field. Thus, inscriptions, like other specialized symbolic objects (e.g., technical vocabulary), differ in the degree to which their meaning is transparent to an audience of novices.

Latour (1987) agreed with Bazerman (1988) when he argued that the aim of most scientific activities (e.g., watching the heavens through a telescope or injecting and dissecting laboratory mice) is the production of tools that translate laboratory work into "findings" via the use of inscriptional forms (e.g., tables, maps, charts, figures, and images). These inscriptions then are interpreted and justified in scientific texts. Latour (1990) insisted that the rhetorical force of inscriptions cannot be understood apart from their use in promoting an argumentative position within a community: "This trend toward simpler and simpler inscriptions that mobilize larger and larger numbers of events in one spot cannot be understood if separated from the agonistic model that we use as our point of reference" (Latour, 1990, p. 41).

Following the model of the scientific and mathematical communities presented by Latour and others, educational reformers are attempting to incorporate both inscriptions and argumentation into their instructional design experiments (e.g., Lehrer, Schauble, Carpenter, & Penner, 2000; Lehrer et al., 2001; Roth & McGinn, 1998). They have found inscriptions useful because they make private thoughts public and visible, they help foster collective classroom arguments, they can preserve a historical record of classroom activities, and they support student engagement in many of the aspects of genuine scientific inquiry.

Clearly, classroom communities and scientific communities differ in many ways, including the obvious differences in expertise and power (Bazerman, 1988). Nonetheless, the socialization of future mathematicians and scientists (as well as informed citizens) begins with discussions in homes and classrooms (Lampert, 1990; Ochs, Taylor, Rudolph, & Smith, 1992). We argue that the use of inscriptions in classroom communities must be coupled with the promotion of arguments if we want to introduce students to some of the essential activities of scientific communities (Lehrer et al., 2001). In addition, we agree with Bazerman when he proposed that learning to use the tools of a scientific discipline (e.g., litmus paper) as well as its inscriptional devices that model the properties of scientific objects (e.g., graphs) involves learning the technical vocabularies and symbolic expressions that are recognized as part of the practices of those communities. Thus, in classrooms, as in scientific communities, arguments need to focus on the meaning of inscriptions as well as their adequacy for advancing a set of knowledge claims.

We begin with a brief discussion of the ways in which classroom communities have differed from scientific communities and attempts within the educational reform movement to create classroom environments that foster scientific problem solving and communication. Next, we depict the role of inscriptions in the agonistic encounters among the many voices of the classroom community in the two instructional episodes. Finally, we discuss how and why the voices of some students are privileged, whereas others are silenced, and why some students seem eager to master the practices of scientists, whereas others show more resistance to that socialization. In our conclusions we address some of the opportunities and challenges of incorporating scientific practices into classroom instruction.

EDUCATIONAL REFORM AND SCIENTIFIC PRACTICES

Inscriptions and Problem Solving in Classrooms

One salient difference between scientific communities and classroom communities is the nature of the problems solved. Similar to the argument made by Lave (1992) and others, scientific problems (like other everyday problems for nonscientists) are dilemma-driven. If mathematical inscriptions are used, they are used to solve actual real-world dilemmas and not as ends in themselves. For Watson and Crick, the double helix was interesting because it helped them solve the dilemma of the structure of DNA—not just because it was an attractive geometric form. In addition, they used their knowledge of chemistry and biology to test the viability of the double helix inscription.

Such use and evaluation of an inscription by practicing mathematicians are very different from the typical activities associated with solving mathematics word problems in school. Word problems originally were designed to help students practice computational skills they had already learned and apply those skills in a slightly different problem context. As Lave (1992) argued, it is not expected that mathematics word problems will inform us about the world outside the problem: They aren't dilemma-driven, and their solutions require using only the information presented in the problem itself (as in a syllogism). Thus, mathematical inscriptions used to solve typical word problems in school are often merely computational exercises where quantities are manipulated, whether they make sense or not (i.e., prices for items may be ridiculously low). Students often recognize this distance from real-world activities and respond by ignoring measurement units in their answers or by failing to check their answer for plausibility (Lave, 1992). In contrast, reforms in mathematics education are intended to support sense making over computational accuracy and speed (e.g., Carpenter et al., 1999).[1]

Roth and McGinn (1998) discussed some of the difficulties that educators may encounter when they try to make classrooms like scientific communities where inscriptions are used to advance arguments about real-world phenomena. These authors argue that inscriptions (and the tools that produce them) come with attributes

[1]Mathematic word problems can be used to foster higher level thinking and argumentation in classrooms, but this type of practice is still relatively rare.

that may afford or constrain particular scientific activities in the classroom (as we saw with the double helix inscription). In any particular inscription, some aspects of the world are highlighted, whereas others are disguised; thus, a teacher's instructional goals must be well matched to the affordances and constraints of a particular inscription.

For example, Fuson and Briars (1990) discussed the affordances (or constraints) of different inscriptions (e.g., linguistic forms, manipulatives, and mathematical symbols) for learning how to use the standard algorithms to add and subtract multidigit numbers. They contended that children's development of base-ten number concepts is constrained by the need to link two disparate, symbolic place-value inscriptions: English words (name–value) and base-ten written marks (positional value; e.g., *seventeen* and 17). They suggest using physical embodiments of the two systems (base-ten blocks and digit cards) to help students understand how physical quantities can be linked to their symbolic inscriptions. In this way, base-ten blocks can afford instruction in the standard algorithms.

In addition, some inscriptions can be confusing to students who have limited experience using them as symbolic models. Sfard (2000) distinguished between talk about material objects (e.g., things or events that exist in time and space) and discussions of mathematical objects (e.g., virtual objects such as lines on graphs). Latour's (1987) work shows that the aim of scientific activity is to turn material objects (e.g., cars rolling down inclined planes) into mathematical objects (e.g., a line on a graph) so that they can be used to defend knowledge claims. Thus, to learn about scientific practice, students need experience transforming material objects into mathematical objects.

Roth and McGinn (1998) pointed out that some students confuse mathematical and material objects. For example, students may misinterpret the shape of a graph representing the velocity of a vehicle over the course of a trip as a literal representation of the vehicle's path. Roth and McGinn called this literal interpretation of inscriptions *iconic confusion*. Literal interpretations can create conflicts during classroom discussions, especially when several inscriptions are combined. Thus, if one wanted to display the velocities of several vehicles (each of which follows a different path) on a single graph, then students who confuse the graph of the velocity with the path of the vehicle are likely to find this condensed inscription confusing. Iconic confusion not only creates miscommunication but also interferes with students' understanding of a fundamental practice of science (transforming material objects into mathematical objects). Roth and McGinn stressed that it is important for teachers to help students articulate the relation between the inscription (the mathematical object) and the object or event that it represents (the material object).

In our detailed analysis of the two teaching episodes, we focused on the affordances of the tools and the inscriptions created by them in the two episodes. Before we turn to the teaching episodes, we outline the differences between discussions in traditional and reform classrooms and arguments in scientific communities. This should help us understand how classroom discussions about inscriptions may or may not resemble the arguments that occur in scientific communities.

Classroom Discourse and Scientific Arguments

Bazerman (1988) proposed the following process for socializing students in the discourse of scientific communities:

> As students move up the hierarchy of expertise in their scientific communities not only do their technical vocabularies expand, but so do their ranges of contact with the subject materials, their abilities to manipulate these materials in congruence with the formulations of their disciplines, their abilities to formulate symbolic expressions in less teacher-constrained situations (that is, taking their linguistic constraints from the materials rather than from sentences fed them in class), and the ranges of interactive processes they are expected to handle with peers and mentors. (p. 306)

According to this view of scientific language socialization, students' meaningful activities with material objects and mathematical objects need to take precedence over their dependence on the intellectual authority of teachers and texts. Instead of memorizing and applying information from authorities, students need to conjecture and experiment. In addition, they need to address each other's argumentative positions and use inscriptions to advance argumentative claims (Lehrer et al., 2000).

Is Brazerman's proposal for the socialization of scientific discourse typically followed in classrooms? Unfortunately, educational research shows that discourse frequently is directed and dominated by the teacher, not the students. A three-part social participation structure typical of traditional classrooms has been identified: an *initiation* by the teacher, a *response* by one or more students, and finally an *evaluation or feedback* from the teacher (I–R–E or I–R–F; Mehan, 1979; Wells, 1993). This social participation structure can be used to represent the following hypothetical exchange between a teacher and her student:

Ms. Jones: What's the answer to Problem 5, Mark?
Mark: 53.75.
Ms. Jones: Is there another way of expressing that answer, Mary?
Mary: 53 and three fourths.
Teacher: Right. Good work. Who has the answer to Problem 6?

In this brief (and quite familiar) example, the teacher calls on individual students, and those students answer questions posed by her and the text. The teacher appears to be satisfied with the accuracy of their answers and does not ask them to explain the strategies that they used or to evaluate the relative adequacy of either answer. Ms. Jones's response after Mark's answer suggests that more than one answer may be correct, and her response after Mary's answer indicates her approval of the stated equivalence relation between a decimal and a fraction. Although Ms. Jones does more than merely evaluate her students' answers in this exchange, her feedback response maintains her position of authority concerning these two different inscriptions of the same number. After evaluating the students' answers, she asks for someone to provide the answer to the next problem and the discussion is likely to continue in a similar fashion. The I–R–E pattern of discourse promotes the following communication norms: The teacher and the text are the intellectual authorities, the teacher regulates conversational turn taking, and students rarely address one another during formal recitation periods. Teachers who want their classrooms to introduce students to the kinds of communication that characterizes scientific communities may need to change the social participation structure of classroom discourse (Lampert, 1990; Yackel & Cobb, 1996). How can this change in participant structure be accomplished? Some educational reformers have been able to document an alternative form of classroom discourse, known as discussion orchestration (O'Connor & Michaels, 1993, 1996), which seems to be closer to Brazerman's position.

In discussion orchestration, students and teachers play different roles than they do in the I–R–E pattern of classroom discourse. That is, the students themselves (not just the teacher or the text) may explain their answers to complex problems. The teacher may encourage students to reflect on and evaluate their explanations and those of their classmates. In addition, the teacher may help the students identify and articulate positions in an argument. Discussion orchestration "provides a site for aligning students with each other and with the content of the academic work while simultaneously socializing them into particular ways of speaking and thinking" (O'Connor & Michaels, 1996, p. 65). Thus, through discussion orchestration, teachers and students articulate argumentative positions, identify proponents and opponents of these positions, and enact the rules for conducting logical disputes that are not socially disruptive. Although these classroom discussions are likely to differ in systematic ways from the arguments of scientists and mathematicians, they may provide a foundation for students' emerging expertise in arguments where factual evidence and theoretical support are required to defend contested claims (Forman, Larreamendy-Joerns, Stein, & Brown, 1998; Krummheuer, 1995; Lampert, 1990).

One primary mean for orchestrating discussions in classrooms is through revoicing (Forman et al., 1998; O'Connor & Michaels, 1993, 1996). Revoicing involves repeating, rephrasing, summarizing, elaborating, or translating someone else's speech. In its most straightforward form (repetition), revoicing provides an additional opportunity for an utterance to be heard, thereby allowing more time for listeners to reflect on the utterance. In its more elaborate forms (rephrasing, summarizing, elaborating, and translating), it allows the listener to reframe the speaker's utterance in a way that can be evaluated by the original speaker as well as by other listeners. In this way, listeners can try to clarify a speaker's utterance by articulating presupposed information, by substituting technical vocabulary for less precise linguistic items, or by further explicating the speaker's intentions. Also, through revoicing, a second speaker can provide needed empirical or logical support for the first speaker's argumentative claim. Finally, revoicing is a means of aligning proponents of an argumentative position.

Another aspect of revoicing, known as animation, is a way that teachers can share their power and authority with students by legitimating their explanations. Goffman (1974, 1981) claimed that the person speaking at any given time (the animator) might not necessarily be the drafter of those ideas (the author) or the person to whom the ideas should be attributed (the principal). These multiple voices are most obvious in the political arena when the position of a powerful political figure may be announced by someone else and may even have been authored by a third person. Applying Goffman's analysis to the classroom, O'Connor and Michaels (1993, 1996) proposed that teachers legitimate student contributions to the discussion through animation. That is, a classroom teacher animates a student by repeating, reporting, rephrasing, or elaborating on that student's ideas. Through revoicing, a teacher can share her power and authority with the student being animated. Simultaneously, animation of a student by the teacher maintains the student's ownership of that contribution. Of course, students can also animate each other or the teacher.

A segment of discourse from the *Batteries* episode illustrates this difference in discourse pattern [12–39]. Jamie expressed her belief that the *Always Ready* batteries were the longest lasting [16]. She aligned herself with Ceasara's argumentative position [12] and opposed her classmate Blake's position [34, 36, 39], asking Blake to justify why he did not agree with her conclusion that the *Always Ready* batteries were the most consistent [34]. During this exchange, Kay, the teacher, orchestrated the discussion by asking clarifying questions without evaluating [e.g., 15, 19, 30]. In general, the students took responsibility for articulating explanations and for evaluating each other's explanations, while the teacher supported this activity by asking for clarification and avoiding direct evaluations. This depicts a very different kind of social participation structure than that represented by the I–R–E.

In summary, discussion orchestration allows the teacher and her students to reframe the content and the social participation structures of the discourse in their classroom. Teachers and students can use revoicing to change the way argumentative claims are proposed, justified, and contested. Also, revoicing can promote shared intellectual authority through the mechanism of animation. Thus, revoicing can be a powerful tool in the creation of a classroom community where students can take the personal and social risks necessary to construct scientific knowledge by engaging in productive intellectual debates about inscriptions.

We now apply the concepts of inscription and argumentation to the analysis of the two classroom episodes. In these analyses, we describe the unfolding of the classroom discussions over time to demonstrate the historical evolution of both inscriptions and arguments in this classroom community. At the same time, it is important to keep in mind the similarities and differences between this classroom's practices and those of traditional classrooms as well as scientific communities.

INSCRIPTIONS AND ARGUMENTS IN THE TWO CLASSROOM EPISODES

The Use of Inscriptions in an Argument During the *Batteries* Episode

Our analysis of this teaching episode focuses on the argument between two groups of students about the longevity of the two sets of batteries. Ceasara and Jamie proposed that the *Always Ready* batteries were the best, whereas Blake argued for the *Tough Cell* batteries. To support their arguments, each side referred to the inscriptional representation of the battery tests and had the opportunity to manipulate the computer tools that generate them. Thus, this contrast between the two argumentative positions shows how the students interpreted the inscriptional forms and used them in their arguments.

Ceasara's explanation of her position in favor of the *Always Ready* batteries was based on her interpretation of the batteries data display. She began this episode by referring to "the longest lasting battery on the pink" [8] and "7 green" [10]—the colors chosen by the software designer to help differentiate the longevity of the two sets of batteries (see Figure 4 in the Appendix, the article by McClain, this issue). Kay quickly revoiced Ceasara [11], substituting the name of the batteries, *Always Ready*, for their displayed color. Ceasara [12] revoiced Kay's linguistic substitution (*Always Ready*) but returned to her color names when she expanded her argument that "7 out of the 10 of the greens were the longest" [12]. Ceasara's choice of words indicates that she was focusing at least as much on the characteristics of the display itself (colored lines of different lengths) as on what it represented (tests of the longevity of two different brands of batteries). This may indicate an iconic confusion: interpreting mathematical objects (lines representing battery life) as if they were material objects (merely colored lines; Sfard, 2000). Thus, Ceasara may have difficulty turning material objects into mathematical objects, a crucial activity for scientific practice.

Later, Jamie revoiced Ceasara by rephrasing her explanation in less literal terms ("out of 10 of the batteries that lasted the longest, 7 of them are green, and that's the most number, so the *Always Ready* batteries are better, because more of those batteries lasted longest"[16]). Whereas Ceasara may have been viewing the inscription literally, Jamie integrated Ceasara's explanation into her own, making it clear that the data display stood for the longevity of these batteries. Thus, Jamie clarified the relation between the inscription and its real-world equivalent. Roth and McGinn (1998) proposed that novices often have trouble differentiating the inscription from the object or event that it represents. These authors stressed that it is important for teachers to help students clarify this relation—an instructional move that Jamie provided for Ceasara in this episode.

Nevertheless, Jamie also shifted the evidential focus of the discussion: from the brand of batteries with the longest life (Ceasara's position) to the 10 longest lasting batteries in the display (Jamie's position). A few turns later, the arbitrary nature of this shift in focus from the number of batteries in each brand that lasted longest to the top 10 batteries in the display was highlighted by Kay when she asked Ceasara to explain why she chose to focus on the number 10 [19, 21]. In her response [20, 22], Ceasara argued that she had examined the 20 batteries represented in the inscription and decided to focus on "half of 20." At this point, both girls had based their argument on the 20 batteries displayed without mentioning anything about the representativeness of this sample. If they were focusing on the real-world problem posed by the batteries inscription, then they would need to consider that the batteries tested would only constitute a sample of the two types of batteries. Thus, both girls treated the inscriptions like typical mathematics word problems in which all the data are contained in the text and not like real-world, dilemma-driven problems where some or most of the data may need to be inferred from the limited data presented (Lave, 1992).

When Blake countered the position advocated by Ceasara and Jamie [30], the evidential basis of the argument shifted away from the 20 batteries displayed and toward seeing the 20 batteries as a sample drawn from the population of two brands of batteries. Blake's initial move was to ask Kay to modify the data display (by repositioning the value bar to 80) to highlight the relation between the type of battery and 80 hr of battery life (see Figure 5 in the Appendix). By doing this, Blake was able to capitalize on the affordances of this tool and its inscription to support his own argument that the *Tough Cell* batteries all lasted longer than 80 hr, whereas some of the green ones (*Always Ready*) did not. Blake also clarified, in his explanation, the relation between the nature of the inscription ("all of the *Tough Cell* is above 80") and the world to which it refers ("So I'd rather have a consistent battery that I know that'll get me over 80 hr than one that just try to guess" [30]).

The difference between Jamie's understanding of the inscription and Blake's became clear when she revoiced his use of the term *consistent* [34] and questioned his interpretation of that term. Her notion that the displayed batteries were the focus of their investigation ("that's only 3 out of 10" [36]) contrasted with his notion that the display represented a sampling from the population of batteries ("they only did, what, 10 batteries? So the 2 or 3 will add up. They'll add up to more bad batteries and all that" [37]). If Jamie had considered these batteries as samples from a larger population, then she might have tried to summarize the longevity data for each set of batteries and mention sampling as Blake did [30, 40, 37]. That is, Jamie seemed to interpret the inscription as a display of all the data of interest (20 batteries), whereas Blake viewed the same inscription as a depiction of one 20-battery sample. These two different interpretations lead, in turn, to two different meanings of the word *consistent*. For Jamie, *consistent* means a greater number of long-lasting batteries among the displayed data; for Blake, *consistent* means a greater chance of buying a battery of a type likely to last at least 80 hr.

Kay revoiced Blake ("more bad ones" [38]) and explicitly mentioned the term *representative*. Unfortunately, Kay did not help the other students understand why representative (as in representative sample) would be a crucial notion to include in their arguments about the batteries. Jessica and Sequoria [42, 48] clarified the practical implications of Blake's argument: that it is useful to be able to predict that you are buying a consistent battery (one that is likely to last at least 80 hr). Nevertheless, it is not clear whether they understood the statistical sophistication of his argument. Thus, all the members of this classroom community may not have shared the meaning of technical terms such as consistent or representative.

Blake's contribution to the collective argument about inscriptions was multifaceted. First, his slight modification of the tool and its inscription (by having Kay move the value bar) made his argument more persuasive and demonstrated his understanding of the affordances of this representation. Second, Blake shifted the evidential basis of the argument begun by his classmates. Blake's explanations also clarified the relation between the nature of the inscription ("all your *Tough Cell* is above 80" [35]) and the world that it refers to ("So I'd rather have a consistent battery that I know that'll get me over 80 hr than one that just try to guess" [30]). Furthermore, Blake was arguing that a consistent battery is one that enables a consumer to make informed decisions, thus articulating the use of inscriptions in the real world.

In the following sets of analyses, we continue our examination of inscriptions, looking at the *AIDS* episode to see how different interpretations of affordances contributed to the classroom argument.

The Use of Inscriptions in the Argument in the *AIDS* Episode

Our analysis of the *AIDS* episode focuses on the students' evaluations of three inscriptions that were used to compare treatment outcomes of two groups of patients. Instead of trying to characterize the nature of the discussion throughout this episode, we restrict our analysis to the argument about Inscriptions 3 through 5 [92–153] because it deals, in part, with a common student concern: the unequal group size of the two treatments.

Before presenting the discussion of Inscriptions 3, 4, and 5 of the *AIDS* episode, we want to highlight their different inscriptional forms. Inscription 3 (Figure 10 in the Appendix) displays the range of both sets of treatment results, divided in half (200–525 vs. 525–850) and the frequency of people who fell in those two divisions (130 vs. 9 in the lower half of the range and 56 vs. 37 in the upper half of the range). Inscription 4 (Figure 11 in the Appendix) contains the same numbers as Inscription 3, but they are displayed in graphical form (along an axis divided into two segments). Thus, Inscription 4 is a translation of Inscription 3: from isolated numbers and text to a geometric format. In addition, the information from Inscription 3 forms one layer of Inscription 4. Inscription 4, however, is no more abbreviated or abstract than Inscription 3. Inscription 5 (Figure 12 in the Appendix) maintains Inscription 4's geometric format and displays the range information but eliminates the frequencies. In their place, lines are drawn to indicate the beginnings and ends of four equal groups of participants in each treatment condition of this study. Inscription 5 could be seen as having been superimposed on the axis of Inscription 4, with the frequency information being replaced by the lines representing proportions of the population in each treatment group. Thus, the movement from Inscription 4 to 5 involves layering and abbreviation.

We begin at the end of the third subepisode, when Marissa questioned the adequacy of Inscription 3 for comparing the results of the two programs of treatment (old and new) that are displayed in this inscription. Marissa said that she found Inscription 3 confusing, "since the old program has more numbers than the new program" [92]. Kay supplied the actual numbers displayed in the inscription to clarify the confusing comparison [93]: "They [the old treatment] had 56 that were above 525, and they [the new treatment] only had 37?" Marissa built on Kay's expansion [94] and argued that the unequal group sizes of the two treatments would make the comparison difficult. Kay [95] called attention to Marissa's concern ("What about what Marissa said?") and made explicit one possible result of using this confusing inscription, "So somebody might say the old program was better because there were more [above 525]" [95]. In other words, Kay voiced one interpretation of this inscription: a counterargument based on an erroneous interpretation of the numbers displayed. In summary, Marissa questioned the value or adequacy of an inscription that interferes with one's ability to make a fair comparison of the two treatments, and Kay helped her elaborate this argument about the affordances (or constraints) of Inscription 3. The transcript of the third subepisode ends at this point.

In the beginning of the discussion of Inscription 4, Paul, the other teacher, revoiced Kay's counterargument from the previous subepisode: that the old treatment was better because more people were in the upper range of this inscription (56 vs. 37) [99]. In response, Blake raised the issue that Marissa had suggested in the previous discussion: that the old program had more people than the new one [101]. However, there is an interesting difference in the way that Marissa and Blake referred to the different treatment groups: Marissa mentioned "more numbers" in the old program [92], whereas Blake said "more people" in the old program [101], a reference identical to Kay's version of Marissa's statement [95]. Thus, it appears that Marissa may have been viewing the inscription literally, whereas Blake and Kay were treating the inscription as a symbolic representation of the real-world testing situation. This distinction is similar to the one we saw earlier in the *Batteries* episode, when Ceasara described the inscription in a literal fashion whereas Jamie and Blake used it to talk about battery life.

After Blake mentioned the problem with the unequal groups, Jason elaborated on his position by suggesting that the numbers, 37 and 56, be examined in terms of a simple proportion [103]. That is, he argued that 37 is more than half the total of the new treatment program but 56 is less than half the total in the old treatment program. Like Marissa, but unlike Blake, Jason was commenting about numbers: "56 is not more than half of 130," instead of 56 people are not more than half of 130 people.

At this point in the discussion, Paul asked for further clarification of the argument being provided by Blake and Jason [105]. When Jason tried to restate his argument in response to Paul's request for clarification, he still restricted his explanation to numbers and did not mention the people in the two groups [112]. In contrast, when Will elaborated Jason's argument in support of splitting each group in half to make sense of the comparison depicted in the inscription, he did mention the people involved [114, 116]. Will rephrased Jason's explanation to clarify the connection between the inscription and the situation that it refers to by mentioning the people in the experiment and by connecting it to the experiment's aim of determining the better treatment. Finally, Derrick revoiced Jason [120] by repeating his argument in favor of replacing the actual numbers with a simple proportion (half the group) and, like Will, he mentioned people.

In summary, the argument evolved during the discussions of Inscriptions 3 and 4 in the following way. The students discussed the affordances of the two different inscriptions. Marissa raised an important constraint of Inscription 3: It did not support comparisons of two unequal groups. Her objection came up again in the discussion of Inscription 4 when Blake repeated it. Jason, Will, and Derrick further elaborated the constraints of Inscription 4, which had the same limitation as Inscription 3. However, the students varied in the degree to which they discussed the inscription literally (as a display of two sets of numbers) or in terms of the situation it represented (the people enrolled in the two experimental treatment groups).

The discussion of the use of proportions in an inscription continued in the final subepisode when Inscription 5 was displayed. In this subepisode, Blake extended the discussion of inscriptions that afford fair, and not confusing, comparisons. He argued that Inscription 5 was better than the others they had discussed because, for each treatment group, the ranges of results were displayed and the distributions were divided into four equal groups (25% of each treatment condition fell between each of the lines depicted) [127]. In the following turn, Kay revoiced Blake's reference to the ranges being displayed. Blake responded by repeating his comment about the division of each treatment into four equal groups, the aspect that distinguishes this inscription from the previous one [129]. In the next turn [130], Kay asked Blake to interpret the inscription for her (and probably for the rest of the class): “So what do you see when you look at this, Blake?” Blake provided his conclusion about the experiment, “That the new treatment was better than the old treatment,” but did not give a literal response to her question (what he sees in the inscription). Thus, she explicitly asked him to supply the evidence for his conclusion [134]: “And what are you basing that comment on?” Blake replied that he understood that the inscription represented the result that three equal groups fell above 525 for the new treatment (75%) versus only one group above 525 for the old treatment (25%) [135, 137]. Blake did not explicitly refer to the people in the treatment groups in his explanation (as he had done in previous subepisodes); however, he connected the inscription to the situation that it represents when he referred to the new treatment being better than the old one.

At this point in the discussion, Marcus indicated that he had something to add. Marcus focused on another affordance of Inscription 5 (its clarity) when he compared it with Inscription 4: “last time like, it was like kind of crooked, and this time it’s easier to see because it’s right under each other” [139]. Nevertheless, Marcus did not seem to find Inscription 5 as easy to read as Blake did, because he suggested that this inscription needed numbers in the groups “so you have a better idea of what you’re seeing” [139]. It is not clear whether Marcus did not understand what Blake meant by four equal groups in this inscription or if he was concerned that the other students might not know the meaning of four equal groups in this context. He did suggest [141] adding 12 to the space reserved for the top group in the new treatment condition (which is approximately 25% of 46), so he may have been suggesting a modification of this inscription for other students, not himself. Thus, Marcus was questioning the adequacy of this inscription for its intended audience (his classmates). He suggested that its meaning might not be transparent to this audience.

Kay followed up on Marcus’s suggestion by explicitly asking the class whether they could read the inscription without modifications, as did Blake (and perhaps Marcus) [142]. That is, she asked whether they could tell how many people were in each subgroup in the inscription without writing in the numbers. At this point, Derrick claimed that they needed to see the numbers [143], and Brian appeared to agree with him [145]. In response, Paul provided the total size of each treatment group (46 and 186), and Kay wrote those numbers on the inscription. This modification of the inscription did not comply with Marcus’s request and did not appear to satisfy Derrick, who suggested that they further modify the inscription to indicate the simple proportion discussed in the previous subepisode: “Divide it into half” [147, 149]. It appears that Derrick was arguing for an inscription that clearly indicated the position of the median for each group, without realizing that Inscription 5 already displayed the medians of both treatments. Thus, for Derrick, the meaning of Inscription 5 was not transparent.

The final set of exchanges in the discussion of Inscription 5 [147–153] ended with Blake's repeated disagreement with Derrick about the need to divide the sample in half: "It doesn't really matter" [148, 150, 152]. Kay asked the other students to stop arguing and listen while Blake explained this inscription. Unfortunately, Blake seemed unable or unwilling to appreciate Derrick's dissatisfaction with Inscription 5, perhaps because Blake found the meaning of Inscription 5 obvious. Blake's elaboration of his explanation [152] was quite terse and cryptic. He said that by subdividing the data into four equal groups, you don't need to know any more information about the data because it is obvious that most of the data from the new treatment (approximately 75%) fall into a higher range than all, but a small proportion of the data from the old treatment (approximately 25%). A simpler explanation would be that the answer to Derrick's question was already displayed in the inscription.

In our summary of the discussion of the *AIDS* episode, we focus on Inscription 5. Blake seemed to be the student who was most comfortable with the affordances of this inscription. He explicitly linked it to the previous inscriptions when he mentioned that the same ranges were displayed [127], but he understood its superiority to the previous inscriptions because the two treatments could be compared directly by examining the placement of the four equal groups [127, 129, 133, 135, 137]. In this way, he showed his appreciation for the power of the different inscriptional forms. Although Marcus aligned his position with that of Blake, he seemed to have found the degree of abbreviation in Inscription 5 confusing (at least to others if not to himself) and suggested adding additional information about the frequencies in each group [139, 141]. Marcus's concerns seemed well founded when Derrick and Brian agreed that information about the frequencies in each of the four groups was needed to make a fair comparison between the two treatments [143, 145]. Thus, Marcus seemed correct in his assumption that some of his classmates may not have understood the meaning of Inscription 5.

Derrick continued [147, 149] to insist that displaying the middle (or median) of the two treatment groups would be needed to disambiguate Inscription 5, despite Blake's dismissal of his argument [148, 150]. This is a suggestion that had been made by Jason (and others) in the previous subepisode when they discussed Inscription 4. Thus, it is clear that some students (e.g., Blake) appeared willing and able to accept the value of the most abstract and abbreviated inscriptional forms, whereas other students (e.g., Marcus, Derrick, and Brian) found this degree of abstraction and abbreviation confusing. In other words, for Blake, the meaning of Inscription 5 was transparent, whereas for Derrick and Brian, it was opaque (cf. Lehrer et al., 2000).

One reason that abstract and abbreviated inscriptions may appear confusing has to do with the tendency of some students to view inscriptions literally (as material objects, not as mathematical objects). Literal interpretations do not lend themselves to combination by layering because they are not viewed symbolically (i.e., as standing for something else). Thus, alterations of the inscription can be confusing if the difference between the inscription and what it represents is not clearly articulated. That may be why Roth and McGinn (1998) referred to literal interpretations as iconic confusions. In contrast, if an inscription is clearly understood as a useful tool for understanding events in the world, then a variety of inscriptions can be compared, combined, or transformed to support or restrict different interpretations. Thus, some students, like Blake, who clearly demonstrate their understanding of the symbolic nature of inscriptions, may find it easy to create and understand complex combinations of inscriptional forms. For other students, who may restrict their focus to the inscriptions themselves, each successive inscription (achieved via layering or abstracting) may seem unrelated to either the previous inscription or to its real-world referent. We saw that several students (Marissa and Jason) restricted themselves to discussing the numbers in the inscriptions, whereas other students (Blake, Will, and Derrick) made sure to mention the people in the different treatment conditions. This latter group of students, based on this limited amount of evidence, appeared to have a better appreciation of the differences between the inscription and its referent. Nevertheless, we saw that Blake and Derrick differed in their interpretation of the meaning of Inscription 5. Thus, it is likely that students who are just learning to interpret and use inscriptions may have difficulty maintaining the distinction between the inscription and its referent after inscriptions are transformed. (See Lehrer et al., 2000, for a thoughtful discussion of the costs and benefits of inscriptions in instructional design.)

Blake seemed to be aware in this episode of the power of complex inscriptional forms. His argument appeared somewhat persuasive to Marcus, who complimented him, but less so to Derrick and Brian. In both episodes, Kay seemed to appreciate and validate Blake's more sophisticated interpretation of the inscriptions. In the next section we focus on the classroom discussions in the two episodes to compare them to scientific arguments. In addition, we examine, in some detail, the contributions of three students to better understand the opportunities and challenges of orchestrating the multiple voices of this classroom community.

ORCHESTRATING THE MULTIPLE VOICES OF THE CLASSROOM

Our exploration of the arguments about inscriptions in the two classroom episodes indicates that the students in this classroom explained, listened to, and revoiced each others' arguments, aligned themselves for or against their classmates' argumentative positions, integrated and elaborated each others' explanations, and interpreted inscriptions. The teachers revoiced their students, asked clarifying questions, and solicited student explanations and evaluations. Thus, students were given an active role in creating knowledge—in the form of arguments about inscriptions. The arguments in this classroom highlight the meaning of the inscriptions and their effectiveness in supporting knowledge claims. In this respect, these classroom practices resemble those recommended by Bazerman (1988) for socializing scientific discourse.

Nevertheless, power relations occur in all communities—scientific as well as educational. Not all participants are on equal footing; not all inscriptions are valued equally. Although our data set from the stats project is limited, we are able to identify individual differences in student social participation patterns that may be instructive in thinking about discussion orchestration in this classroom and others. In the concluding section, we speculate about the orchestration of the multiple voices of the classroom community, using examples from the two subepisodes from the stats project. We discuss this issue by focusing on the contributions to the classroom argument about inscriptions by Blake, Derrick, and Marissa, because they represent distinct examples of the ways in which some students are silenced and others are privileged in classroom discourse.

We begin with a discussion of Blake's contribution to the classroom discourse. Blake's voice was distinctive for several reasons. First, he seemed to understand the power of inscriptional forms better than the other students. He used their power to make his arguments more persuasive. In addition, he sometimes integrated the words of other students in his arguments to increase their appeal. Second, Blake appeared to understand and use sophisticated mathematical terminology. When Kay expanded on Blake's argument in the *Batteries* episode with words such as "lower limit" and "representative" [33, 38], Blake gave tacit approval to these terms. In the *AIDS* episode, Blake appropriated the statistician's voice in his explanation by distinguishing between data (the entire distribution) and groups (subsets of the data). Third, Blake seemed comfortable moving from inscriptions to the real-world dilemmas that they represent (choosing batteries or AIDS treatments): He rarely described inscriptions literally but rather differentiated inscriptional features (e.g., colored lines) from the data they represented (e.g., battery life). Finally, he seemed to understand the role of statistical sampling in the creation of the inscriptions used in the two episodes. In both episodes, Kay frequently legitimated his voice through revoicing. In the *AIDS* episode, Kay went so far as to tell the other students to keep quiet while Blake explained because he had something important to say. Thus, Kay legitimated Blake's contribution over those of many other students and rewarded his alignment with the teachers (i.e., the mathematical experts) in the classroom. Unfortunately, Blake's appropriation of mathematical language and Kay's privileging of his explanations may have created a social barrier between Blake and his classmates. This possibility is even more apparent when one examines Derrick's classroom social participation practices.

Although Derrick's voice was not heard during the *Batteries* episode, he was a frequent contributor to the *AIDS* episode. Derrick stands out from the other students in the *AIDS* transcript for several reasons. First, he received a large number of negative evaluations of his behavior. In Subepisode 3, for example, Kay and some of the other students sanctioned Derrick repeatedly for not attending to the class discussion [83–87]. This sequence also recurred in Subepisode 4 [108–111]. Nevertheless, Derrick adopted many of Kay's behaviors; for example, he sanctioned other students (Jamie, Jason) for not speaking loudly enough [107, 110]. Although Kay rarely evaluated students' explanations, she frequently sanctioned students who did not speak distinctly enough for others to understand. In addition, Derrick, like Kay, frequently revoiced other students.[2] Thus, Derrick presents a complicated picture of a student who seemed to violate the teacher's classroom communication norms yet who adopted some of her communication practices.

In addition to Derrick's role in the social dynamics of this classroom, he showed, through the content of his utterances, that he was following the discussion of inscriptions very closely. For example, in Subepisode 4 [120], he revoiced Jason's comparison of the two distributions based on their median value. In Subepisode 5 [147, 149], he continued to argue for the value of the median (that would allow you to directly compare the 50th percentile in both groups). Unfortunately, Derrick didn't seem to understand that Inscription 5 included this piece of information while providing additional information about the distributions. Blake countered Derrick's position [150,152] when he claimed that "it doesn't really matter"—meaning that the quartile distribution already contained information about the median. Unfortunately, the transcript ends before we can see whether Derrick had a chance to reconcile his position with that of Blake.

In summary, Derrick was quite active in this lesson, but his activity seems contradictory: He both challenged the teachers' authority (by refusing to pay attention at times) and assumed their authority (by evaluating and revoicing other students). He also kept abreast of the mathematical issues being discussed. Although Kay did not prevent Derrick from contributing in a productive way to the classroom discourse, despite his occasional oppositional behavior, she did not privilege his explanations as much as Blake's. At the end of the *AIDS* transcript, it is apparent that Blake's explanation was seen as the powerful one whereas Derrick's was seen as deficient, at least by Kay (because she silenced Derrick so that he and the others could listen to Blake's "important" argument in support of Inscription 5).

Why did Derrick act in a way that seems contradictory—both endorsing and opposing the practices of this classroom? One interpretation of Derrick's behavior is that he was opposing the unequal footing of adults and adolescents. We would argue that part of the answer comes from the inherent conflicts, especially for

[2]All instances of revoicing in the two episodes were identified and coded by the two authors. We found that Blake and Derrick were responsible for the largest number of revoicing moves by students in the *AIDS* episode (15% and 14%, respectively). In contrast, Kay, one of the teachers, revoiced students 57% of the time in this episode. Because of space limitations, a full presentation of these results is not given.

working class adolescents, between the norms of the peer group and the norms of the adult-dominated classroom (Mehan, Hubbard, & Villanueva, 1994). Although the discussion orchestration form of classroom discourse (that predominated in this classroom) may be a good one for socializing scientific discourse, the teachers and their students still were not on equal footing. By acting like Kay and Paul (by revoicing and evaluating other students), Derrick challenged their right to act like the sole authority figures. However, his challenge also aligned his position with Kay's when he used her authoritative speech. These conflicting alignments may have resolved some social conflicts for Derrick: They may have allowed him to demonstrate his knowledge of and interest in the academic material without threatening his status with his peers. In addition, Derrick's demonstrations of resistance to the communication norms of this classroom may have provided him with the means for making its discourse his own. In this way, he could modulate the official mathematical language (median, mode, scale, range, distribution) with his own accent, his own intentions (Bakhtin, 1981). In contrast, Blake seemed willing and able to adopt sophisticated mathematical language without conflict. This may indicate that Blake was more willing than Derrick to align his position with the experts (his teachers) and not with the novices (his classmates).

Finally, we would like to mention Marissa's role in the *AIDS* episode. We began our discussion of this episode with Marissa's comments about Inscription 3 because we believed that this was the beginning of an important discussion regarding the affordances of Inscriptions 3, 4, and 5. Although we saw the argument as beginning with Marissa, her authorship was not mentioned when Blake, the teachers, and her classmates raised the topic again during the discussion of Inscription 4 in the following subepisode. Of course, without knowing what occurred between these two subepisodes, it is impossible to determine why her voice is not included in the later discussion. Her name only appears in one subepisode of this transcript. In addition, none of the other girls in this classroom contribute to the discussion after Marissa's critique of Inscription 3. Therefore, the limited information available about the larger context of instruction prevents us from speculating further about the silencing of girls, in general, or Marissa, in particular. Nevertheless, the power of revoicing to legitimate student thinking can be diminished significantly if the significant contributions of one or more students are forgotten as the discussion continues.

Our exploration of the contributions of Blake, Derrick, and Marissa to the classroom discussions shows that different students present different instructional challenges when one is interested in promoting discussions based on inscriptions in classrooms. Some students, like Marissa, make important contributions early in the discussion and then are forgotten; other students, like Derrick, make contradictory contributions (disruptive and productive) and may be ignored or underestimated; other students, like Blake, may make important and sophisticated contributions and are privileged. Each of these outcomes could change the nature of subsequent discussions for these and other students. They also could change the nature of the social dynamics in the classroom (e.g., where the students who are privileged by the teachers may be shunned by their classmates).

CONCLUSIONS

What have we learned about classroom practices from examining the use of inscriptions to promote argumentation in the two episodes from the stats project? We found that we were able to draw parallels between the practices of scientific communities and the practices we focused on in this classroom. At a general level, both communities used inscriptions of real-world events to anchor and adjudicate scientific arguments. That is, the affordances and constraints of inscriptions can serve as material for evaluation and debate in both communities. In addition, both communities were able to transfer and layer inscriptions to more adequately represent data. In both situations, inscriptions have a history and create a permanent record of the community's history (see Lehrer et al., 2000). Also, in both communities, intellectual authority was shared among the participants even though power relations continue to operate. That is, footing or power can shift, sometimes moment to moment, as new arguments are presented that integrate or seriously counter the earlier arguments that had seemed more persuasive.

In addition, we have seen that the teachers and students were able to change the social participation structure of this classroom from the I–R–E to discussion orchestration. We saw that both teachers and students were involved in revoicing each other and in listening to, reflecting on, clarifying, expanding, translating, evaluating, and integrating each other's explanations. Both teachers and students legitimated student explanations. We found that the teachers and students played complementary as well as similar roles: The teachers tended to solicit arguments from students, whereas the students provided explanations and evaluations of their classmates' explanations.

Nevertheless, to understand the educational functions of the classroom arguments about inscriptions, one needs to go beyond the discourse itself to look at the kinds of problems used and the inscriptions depicted. We found that the problems (deciding which battery to buy or which AIDS treatment to recommend) were unlike typical mathematics word problems because they were realistic and dilemma-driven, not self-contained or arbitrary. Thus, the inscriptions needed to be understood as merely one or more possible representations of the data that one might gather in a real-world situation. In addition, we found that the inscriptions available in the two episodes were used to ground as well as to counter argumentative claims and to align students on different sides of the argument. Finally, as Latour (1990) suggested, some students were able to appreciate and capitalize on the power of the most abbreviated, layered, and abstract inscriptional forms.

We also found that the classroom arguments allowed us to speculate about the multiple voices of the classroom. We saw that the arguments of some students were privileged by the teachers, whereas the voices of other students were legitimated at one time and silenced at another. Nevertheless, because the students also revoiced each other, it was possible for students to animate and thus legitimate each other. In this way, arguments that seemed less sophisticated from a mathematical standpoint were given some validity and could serve as starting points for the development of future, less literal, more abstract and general inscriptional forms. Thus, the classroom discourse was truly multivoiced despite the inherently unequal footing of teachers and students.

It is important to attend to the multiple voices of the classroom community; if we do not, we may fail to recognize important instructional opportunities. At the end of the *AIDS* transcript, Blake appears to be the competent student, Derrick appears to be the slower, less cooperative student, and Marissa's voice is missing entirely. This event leaves us with an important question for future instructional interventions: Can we devise learning environments where students like Derrick and Marissa can effectively challenge students like Blake without threatening their peer group status or their sense of their own intellectual authority? In such a learning environment we might discover that Derrick and Marissa are capable of connecting their understanding of the last inscription with Blake's.

Our examination of the two classroom episodes from the stats project has shown that classrooms can begin to resemble scientific communities when discussions incorporate arguments about inscriptions. Drawing parallels between scientific communities and classroom communities has enabled us to conceptualize the value of promoting new models of classroom organization and new instructional goals. The difficult task of designing classrooms that foster the productive use of inscriptions in the service of scientific argumentation has just begun. As more examples of these kinds of classrooms are made available, their advantages and limitations can be identified.

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