THE JOURNAL OF THE LEARNING SCIENCES, *11*(2&3), 373–386

A Commentary on Instructional Design

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As we hope for the students of the stats project class, every task has its lessons. My task has been to find a way of speaking across this special issue of immensely detailed reports devoted to the analysis of a highly disciplined project of instructional design in math education.

Of all things, the detail stands out, both the naturalistic detail of the stats project and its classroom records, and the detail of the conceptual–analytic distinctions and refined conjectures that we find in the collected articles. There are multiple analytic programs and complex architectures across the contributions to this special issue, and they are all about math education. It was a challenge for one whose credentials in math are long gone, and no doubt there is much I have missed. On the other hand, if we can ever parley a deficit into a modest virtue, it also may mean that I have found this special issue much as an interested, but none-too-expert reader might. This commentary is thus a reader's exercise and has come to entail taking an interest in the materials in ways that the designers and authors may not have intended.

Let me begin with the purpose and format of this special issue. I am not certain of the specific instructions delivered to the contributors, but the evident shape of the issue is that of a collective address to a same corpus of materials, in the particulars of the stats project class. The seriousness of the project, its history, purposes, preparations, development, and execution, are nicely and effectively captured in the Appendix by Kay McClain. We find further insights in the contribution of Paul Cobb and in the second contribution of Kay McClain. Their histories with the project's design and implementation informed their analyses of what the materials show us about "mathematical learning in the classroom community" (Cobb, 2002/this issue). McClain offered a distinctively professional field of view in her analysis of the records as records of her own professional work and how analytic and design distinctions can become elusive things in the welter of classroom teach-

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ing. Paul Cobb's treatment displays such a deep history with the project, including a history of prior study and publication, that it is difficult to imagine a question that was not anticipated in the extant analysis or could not be answered by a prior one.

We can see as well a diverse collection of interests and purposes across the articles. Although the organization of the special issue—multiple perspectives brought to bear on a same set of materials—could be mistaken as a kind of "logical–empiricist" moment, in which different lenses set off to find and even "triangulate" a same object, what the contributors did with these materials sets that worry aside. Geoffrey Saxe used the corpus to further develop his continuing and distinctive inquiries into the "interplay between cultural and developmental processes in children's mathematics" (2002/this issue, p. 276). Forman and Ansell and Schliemann wrote more discourse-analytic accounts, each finding different discursive organizations and different reasons for taking interest in them. Anna Sfard took interest in the discourse, too, but found a "dialectic" that showed still other, perhaps prediscursive orders of communication. The collection is both diverse and coherent. Although we find an array of interests and methods, it would be difficult to locate actual disagreements or imagine places where the contributors could not come to a working consensus about what is interesting about the stats project's corpus and how we could be instructed by it.

A DOUBLE FIELD

For readers, however, the relevant fields are somewhat different. We are looking over the shoulders of these analysts, and we can say fairly that two fields come into view: The work of the students as captured in the transcripts and stats project accounts, and the work of the analysts in capturing the work of the students. Within the first field, the students' task was to engage the data displays as features of their curriculum and as pending objects of uncertain shape, organization, and use. Their task was to objectify them in some way, to find them as useful, stable, even fungible objects, and to find across them an organization of statistical principles, where finding them and deciding what can be done with them would be the reflexive achievements of their learning. Their growing confidence in assessing the AIDS inscriptions, for example, may be some evidence of how they grew to the task; we could say they were domesticating the tools to their tasks as they now knew them. The characterization, however, begs the question: Domestication to what: to math, or to other, different orders of reasoning and action?

The question animated the analyses as they took up the activities of the students to find evidences of larger, formal–disciplinary and developmental organizations, and math learning specifically. This is the second field available to the reader, and in ways it is the more vivid field, certainly the more articulate one, and the one I want to consider in this commentary.

In doing so, however, I risk the charge of "pointing to the finger" rather than what the finger is pointing to.[1] At its worst, the exercise can displace a common interest in understanding the stats project's curriculum with talk of "method" or analytic "deconstruction." There are precedents. But if we acknowledge the risk, it may be worth it if, in the end, we can say something useful about how indeed we are pointing and can affirm the larger wisdom that how we do is a constitutive feature of what the finger finds. With this purpose in mind, I want to consider further what this special issue shows us about the work of instructional design and its analysis. We can't help but be impressed with how the recursive contingencies of the design process shaped the records that became the stats project's corpus. We heard of it most directly in the Appendix (and in McClain's [2002/this issue] remarks on how the designers examined and revised the curriculum daily). Although we cannot address the project's design work too closely, we do find an opening in the central place of inscriptions for the project and the collected analyses. I want to begin there.

INSCRIPTIONS AND AUTHENTICITY

Latour and his colleague's work on inscriptions (Latour, 1987, 1990; Latour & Woolgar, 1986) has been thematized in the education literature as part of a more general discourse on "authenticity," wherein inscriptive, discursive, and other mediating practices are understood as constituent features of the authentic professional practices we propose to teach in our curricula.[2] It is also part of a more general discovery of post-Kuhnian studies of science in science and math education. Inscriptions have been discovered for the promise of new and more faithful accounts of what the practice of science really is, displacing more mythic versions in the process (see, e.g., Roth & McGinn, 1998). Displacing prior understandings is indeed part of what contemporary science studies have done. Although the pur-

[1]The phrase is borrowed from Schegloff's (1999) reply to Billig's (1999) critical discourse analytic critique of conversational analysis. The usage here, however, is reversed: Schegloff was speaking on behalf of what indeed the analytic finger of conversational analysis is pointing to. Nor is my commentary a political one (and certainly not a "textual" one). It rather follows from a practical sense that the second field is, for the reader, at least as instructive.

[2]Although this is a new and promising analytic discourse for us, it is fair to observe that the pursuit of authentic curricula has been a familiar lever of critique and reform for all of modern education. (See Atkinson & Delamont, 1977, for a report of a 19th-century program for teaching classroom science "in the attitude of the discoverer" [p. 88].) Expressed in the analytic theme of "reproduction," the pursuit of real worldly knowledge has framed much of the critical discourse on classroom teaching, and in this relation to the world, classroom education was equipped from the outset with a language of evaluation, critique, and reform. We can understand much about the history of reform in terms of this abiding relation.

pose—to lend some correction to received images of science in science education—is more than agreeable, it may be useful to consider how the program of the new studies of science seems quite different.

A distinguishing feature of post-Kuhnian studies has been the critique and abandonment of the canonical project of science studies, namely, the pursuit of demarcation criteria that might (finally) decide what science is as an enterprise *sui generis* (cf. Bloor, 1976; Collins, 1985; Knorr-Cetina & Mulkay, 1983; Lynch, 1993; Pickering, 1992). Inscriptions have become an object of interest in science studies not because they offer an answer to that question but rather because when we begin looking at science as an order of everyday practice, we find inscriptions underfoot in the work of assembling findings, arguments, and claims. Inscription is not then a criterion of science but rather of a piece with its description as a professional, and even quotidian, practice.

However, the context of inquiry for science studies is quite different than the design projects of educational studies. Criteria are precisely what the design enterprise needs, and not only because of the aims of discipline-based, reproducible instruction, but because in the instruction of novices, it won't do to say that "nothing is settled."[3] This may be why instructional design innovations tend to become normativizing exercises, with novel norms, for which inscriptions (and "tools") may be operating as a most recent iteration. Understandable as it is, we then reinscribe the very demarcation exercise the abandonment of which is perhaps the defining move of the studies of science that have given us such things as inscriptions.

In this light, inscriptions may be more useful for building our descriptions of classroom practices than for certifying them, and once they come into view, it is difficult to decide when we will stop looking. The design process itself and the collected analyses are densely inscribed. Through the minitools, displays, and tasks presented to the students, the stats project itself became an inscription apparatus for the students and, substantially, for the contributing analysts.[4]

THE WORK OF INSTRUCTIONAL DESIGN AND ITS ASSESSMENT

The stats project's design history thus tells us something of how the organizations of student thinking and learning that we hope to find in the episodes were already

[3]We see the tension in McClain's critical (overly so, in my judgment) self-assessment of her work in shaping the students' discussions.

[4]It was a feature of Latour and Woolgar's (1986) account that for practitioners, "forgetting" the practical history of inscriptions-in-use was a constituent feature of their familiar use (unless given a practical motive, as in deciding the difference between signal and noise, or finding and artifact; see Lynch, 1985).

"inscribed" in the territory that the project intended to map.[5] Both the ad hoc inscriptions (e.g., the handwritten graphs in the *AIDS* episode) and the minitools were closely attended features of the project's recursive designs. They were measured to the very affairs they hoped to detect, for example, discursive practices or multiplicative reasoning. The very notion of "supporting" certain mathematical practices is at once the design task of "impelling" them in some useful way, and instruction would be merely showing (or testing) and not teaching, were this not so. At the same time, this intertwining organizes the design's own possibilities for assessment, whose task becomes one of recovering the marks of the design in the practical enactments of the students.

This is, of course, a reader's account of the work of design as we find it in the several accounts of the project, and I offer it to context the following interest: After the field had been infused with the designed curriculum, the analytic and assessment tasks became ones of discerning the curriculum's evidences in what the students were doing, and a good deal of this special issues shows us ways in which those discernments could be done. Generally, it became a task of "looking through" what the students could be seen and heard to be doing, to find the evidences of design-relevant (or math-relevant) order, reasoning, and practices.

The looking is organized by an array of conceptual–analytic distinctions that are, in the main, leveraged from a first distinction between something like "ordinary" and "mathematical" thinking. The alternation between the two may be the central analytic distinction across the collection. It can be seen, for examples, in Cobb's formulation of the difference between "models of" informal reasoning and "models for" mathematical reasoning (p. 35), as it can in Forman and Ansell's distinction between "material objects" and "mathematical objects" (2002/this issue, p. 252). Each stands on behalf of a divide between vernacular and disciplinary knowledge and action. "A model of informal reasoning is tied to particular task setting and involves situation-specific imagery, whereas a model for more general reasoning is independent of situation-specific imagery" (Cobb, 2002/this issue, p. 209).

The formulation is a venerable one. It is also the binary that has been problematized by contemporary studies of science and education.[6] We might better understand "situatedness" as a unifying formulation, rather than the lesser item to a formal pairing; "formal knowledge" owes to situated coherences too. This is a large argument that has been pursued elsewhere (Lynch & Macbeth,

[5]As McClain (2002/this issue) explained, "The research team mapped out a hypothetical learning trajectory…[and] the two computer-based tools we developed were designed to offer resources that would support the emergence of the conjectured learning trajectory" (pp. 222–223)

[6]See, for example, Livingston's (1987) analysis of the visual proof of the Pythagorean theorem for how the proof is densely tied to a visual field, Goodwin (1994) on "professional vision," and Lynch (1991) on "topical contextures." Lave and Wenger (1991) took it up directly: "What is called general knowledge is not privileged with respect to other 'kinds' of knowledge. It too can be gained only in specific circumstances. And it too must be brought into play in specific circumstances" (p. 34).

1998; Macbeth, 1996), but the tension it points to is recurrent in the collection. It establishes the central task, both for the design and for its analysis, as a "gap closing" exercise, in which we would be led to witness how the one—the students' presenting practices of arguing and navigating data displays—becomes the other—demonstrably disciplinary math.[7]

The question is, of course, the question of learning and is entirely sensible. When framed in binary terms, however, it unavoidably becomes one of "looking through" what the students were doing in the practical course of their lessons, to find mathematical reasoning and practices (e.g., inscription practices). This is so because each of the collected studies was more or less committed to a naturalistic study, if only in virtue of the stats project's records (i.e., the real-time records of the students' discourse, arguments, and interactions), and as such each encountered the problematic of working from the "surfaces" of what the students were doing. Perhaps the central means for looking through them entails an exercise of translation, or captioning, in which what they were doing is described in math-relevant terms.

The transcripts become particularly relevant here, and we find across the collection several analyses of certain words and expressions that the students used. Cobb, for example, took up the use of the terms *majority* and *most* to argue that across the episodes "relative frequency had been established as the normative meaning of majority" (p. 203). But *majority*, like *most*, may have too many attachments in common parlance and may be too useful in too many ways to insist on only one of them. In a similar exercise, Forman and Ansell found in the expressions *more numbers* and *more people* the difference between "viewing the inscription literally [and] treating the inscription as a symbolic representation of the real-world testing situation" (pp. 260–261), although it is unclear how one is more literal, or symbolic, than the other. Each is a cogently unremarkable way of speaking in the course of their lesson, and sorting the math between them strikes me as a fitful exercise.[8]

Similarly, the use of the word *consistent* recurred in the transcript of the *Batteries* episode and in the analyses that followed, as a matter of what mathematical reasoning can be found in it. We find its most dense captioning in Sfard's account of a "three-partite discursive focus of pronounced focus, attended focus, and intended focus" (see p. 328 and its inscriptions). Thus, a very great deal is found to

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[7]The encounter may have been most directly addressed in Saxe's attempts to forge an alignment between the local and formal orders in his treatment of microgenesis.

[8]Forman and Ansell noted that Blake, who spoke of "more people," did so after Kay, the teacher, spoke that way. Rather than deciding that he and Kay therefore owned a same symbolic vision, we could figure that their usages were consecutive, and that Blake heard in Kay's reformulation of Marissa's prior answer ("more numbers") a relevant way of speaking. That the terms of its relevance were statistical, however, isn't something that the record can settle. We only have them as the sequentially produced utterances they were (i.e., as usages built in interaction), and we need far less conjecture or inference to sustain that hearing.

stand behind a very ordinary word, and Cobb pressed further still to consider what the students did *not* say (11).[9]

The move whereby we find the math in the surfaces of their remarks and interactions is a decisive one for the analysis. I want to say it is a way of writing the relevant math "into" their discourse. It permits us to find math already on the scene, and it's not that it may not be. The difficulty is entirely an analytic and descriptive one, that is, to find math in the contents of their words and, by implication, what math they had in mind. By Krummheuer's account (1995), interaction and the talk it produces are far too variegated for that, and there is "no direct access by (collective) argumentation or any other kind of interaction to…individual cognitive process" (p. 267).[10] Said differently, that a math-competent reader can render what the students are saying in statistical–logical terms is not quite an answer to the question: What are *they* doing? It may be a far more vernacular task for them, no doubt with some math attachments.

CONJECTURES AND REFUTATIONS

To continue the reader's account, the practical task of the gap-closing exercise becomes one of establishing that the students were indeed crossing the divide that the design premised, and for which it designed an oblique array of footholds embedded in tools, inscriptions, and practical instructions. The analytic task is then one of discernment and demonstration, or showing from the transcripts, in the main, that we are indeed seeing a crossing over.

It becomes, unavoidably, a matter of argument, and there are many ways of building them. As one who reads ethnographic and discourse–analytic work more commonly than instructional design literatures, I was struck by a recurrent form of argument across the collection. It is the formal structure of "hypothesis," or, in the particulars of Cobb's, McClain's, and Sfard's discussions, "conjecture and refutation."

The phrase presumably borrows from Popper's (1959) critique of logical positivism. Although influential in its time, it has since been examined and critiqued as itself a substantially positivist account of the construction of scientific knowledge. (See Kuhn, 1970, on Popper's "logic of knowledge.") Generally, it runs aground

[9]Elsewhere, Schielmann offered grounds for a very different reading of how Caesara and Jamie used *consistent*, namely, that their reading and reasoning about the batteries displays were "analogous to how one would judge the performance of two teams of runners. The team with more runners in the top places wins" (p. 305). This is at least one other way in which we could hear the use of *consistent* across the discourse.

[10]Krummheuer may have been pointing to ethnomethodology's long-standing distinction between "rational" action and "reasonable" action, and there is much that the students did and said that was reasonable, with no need for a mathematical provenance.

on the practical difficulties for refutation, given the "underdetermination" of what any set of observations can compel as a conclusion (Quine, 1964). Theories, the canonical form of conjecture, are seldom successful, nor are the successful ones explainable, that way, and if refutations are elusive things in the natural sciences, the chances for finding them in social science seem more difficult still. We can certainly have our conjectures, but they will be indefinite, unstable, and, moreover, without closure. In this sense, the phrase works more as an allusion than a description, itself a part of a developing course of argument or persuasion, and it is unclear what the conjectures can settle.[11]

Some kind of alternative analysis has been lurking behind this reader's commentary, and I want to sketch it briefly. It has to do with how we understand the relation of ordinary practices to disciplinary knowledge. (See Lynch, 1993, for a direct address to the question.) It is a very large topic in ethnomethodology and contemporary science studies, and we can say it follows from the abandonment of demarcation criteria. It is not that disciplinary knowledge is then only a matter of ordinary practices, but rather that a different "topography" comes into view, wherein "the 'grand dichotomy' with its self-righteous certainty [is] replaced by many uncertain and unexpected divides" (Latour, 1986, p. 2).

In classrooms, we teach our lessons through practical fields of tasks, activities, and ways of doing them that the students can competently navigate, notwithstanding that they don't *know* their lessons yet. Thus they find their lessons, which they don't know, through practical tasks, which they do know. In this way, the competence we find in classrooms—the teaching and learning—is tied to the very enactment of their lessons, which is overwhelmingly, as we find in the stats project class materials, discursive and interactional. In this light, and in the particulars of the project, we can differently begin to answer a question that each of the analyses took up and answered in its way: When is statistical understanding first found? The alternative rejoinder is that whenever it is, it is unlikely that it's found first. Rather, students find their mathematics lessons in fields that are familiar, practical, and vernacular (i.e., in tasks that they know and can do), and we may be on more secure footing if we treat the records that way. We then can ask how a student who is learning—but has not yet learned—statistics and the mobilities of data displays might approach one, take it up, fiddle with it, and see what kinds of practical things might be done with it, while talking through the work of doing so. I want to suggest that this is roughly what the students, or at least some of them, did with the class materials and also to suggest how we might build that description.

[11]Of course, conjectures, hunches, and the like are enormously useful things in all sorts of practical crafts, as any hobbyist or repairperson will tell you. It may be that the work of instruction design is practical in that way too.

To do so, I want to briefly review Geoffrey Saxe's account of what "prior understandings" or "intuitions" the students might have brought to the data displays. We are all quite agreed that the students had them, and Saxe's analysis targeted mathematical or statistical ones. They are the "ground from which children create particular goals" (2002/this issue, p. 288), where these too are understood as mathematical goals. His analysis delineated four of them. The students could be seeing the *Batteries* display as follows:

1. Depicting individual cases.
2. Depicting groups composed of individual cases.
3. Depicting groups sampled from two populations of cases.
4. Depicting two groups sampled from two populations, where *n* is a variable (pp. 288–289).

These are careful formulations of the statistically relevant intuitive possibilities that the display might support (although the analysis offered no evidence in the students' performances of the first or the fourth). They are things the students "could conceivably" have been doing. They are also descriptions of what the design afforded. Yet the materials suggest still other kinds of indefinite, but evident and practical, "intuitions" that might have organized the students' approach to the materials. They are intuitions about the "surfaces" of the displays and how we can find in those surfaces an organization of practical objects, interests, and accounts, meaning ways of making the display a thing that we can speak of, propose about, and build accounts of possible activities it could sustain—and thus render it available to "data–based justifications" (The numbers refer to transcript lines):

1. That the display was a display of ordinary objects—batteries—some of which were green, some pink.

2. That the display showed those that lasted the longest and those that lasted the least [8].

3. That these ordinary objects attached to ordinary worlds, and thus if required to "animate" them in some way (to build an account of what they can "do"), we can do so by creating "cohorts" and take their measure that way (see [8–12]; this is an analog to Saxe's second intuition, listed previously).

4. That this work entails "formulating" or saying in so many words what we mean and what we're talking about. For example, Jamie [16] nicely formulated Ceasara's practical account, in a way that was thoroughly practical as well.

5. That the students (intuitively) saw that these ordinary objects had a life "beyond the grid." The grid—the order of the display—is not coextensive with the things it orders. Thus, we can move the grid "over" its objects, realign the grid, and

thereby recast the objects, and in so doing discover resources for building alternative and competing accounts of what indeed we are seeing (see Jason [18]).[12]

6. That once we have competing accounts in hand, the first resource for arguing the matter is practical too: We offer up alternative measures of "goodness," such as consistency or risk, and argue how they are to be measured as a practical matter. For the students, justification intuitively became a storyable matter of practical reckonings, wherein we embed our assessments within unremarkably familiar courses of action, for example, "If you were using those batteries for something important then you might end up with one of the bad batteries " (Jessica [42]).

These were also "intuitions" about the display, but about matters of *use*, not math. Rather than mathematical, they were only, and especially, practical and reasonable. Although the curriculum was designed to yield mathematical understanding, to do so it must afford something like practical understandings, and indeed it does, and the researchers who designed the curriculum similarly observed: "The students typically engaged in these types of tasks to make a recommendation to someone about a practical course of action that should be followed" (McClain, 2002/this issue, p. 164). I am suggesting that this is more than an anecdotal report. It points to a structure of activity or practices that is not only prior to the math of the lesson but formative of the math's very possibilities. In my view, it is not a critique to observe that the students were "attempting to 'do something with numbers' to satisfy a school requirement" (McClain, 2002/this issue, p. 164). They were in school, and doing something with the displays was indeed their task, and in whatever measure they found the math, they did so by first navigating a field of practical and discursive tasks, artifacts, instructions, and rejoinders.[13]

The goals that the students showed us might not then be the goals of math but the goals of their lesson *in* math, namely, to collaboratively produce and enact a novel curricular activity, discover its terms and measures (including the expectation that they will produce "data driven justifications"), and bring it to completion in a way that usefully demonstrates and teaches the relevant lesson.[14]

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[12]We may be seeing something of what Rogoff (1990) concluded from her review of the cognitive skills of schooled and nonschooled children: "Schooling fosters perceptual skills in the use of graphic conventions to represent depth in two-dimensional stimuli and in the analysis of two-dimensional patterns" (p. 47).

[13]See Lynch and Macbeth (1998) on classroom physics demonstrations in the early grades, and how we could usefully regard classroom science, and now math, as orders of science and math in their own right, and then begin building the descriptions of what kind they are. Saxe may have had something similar in mind when he spoke of "children's mathematics."

[14]This can be a useful way of thinking about classroom lessons and their artifactual and actionable demonstrations more generally: the lesson is to be found in the demonstration's enactments, and the demonstration is produced so as to find (and demonstrate) the lesson (Macbeth, 2000).

CONCLUSION

I want to conclude by returning to my reader's account. I began by observing that we find in this special issue a double field of view: a view of the students at work on the stats project's tasks, and a view of the designers and analysts at work on theirs. If the account is read in a certain way, a kind of double vision ensues as well, in which we begin to see each cohort—students, designers, and analysts—engaged in their tasks in ways that may show no privileged grounding for any of their inquiries, in the following sense: Each cohort, or all of us, is in the business of making sense of our enterprises from the surfaces of things, of inscriptions, artifacts, tools-in-use, instructions, answers, accounts, and skepticism. We encounter fields of situated order, meaning, and action and set out to navigate and decide "the rational properties" of the "indexical expressions" that we find there (Garfinkel, 1967), meaning how we make sensible and reasonable (and even logical and mathematical) social expressions that are themselves fitted to local tasks, contexts, and purposes.

Our tasks and goals are not nearly identical, but our circumstances may be remarkably so, and Sfard offered a very suggestive phrase that may capture what is common across these fields. Though she too spoke of "conjectures and refutations" as an account of the analytic–design work, the larger rubric may be the one she assigned to the students only: "intimations and implementations." As a caption, this strikes me as at least as promising for understanding the work of instructional design as well.

It is, however, a delicate characterization. Seen that way, the work of design begins to take on the character of a "practical craft," meaning the phrase much as Kuhn used it to describe the fields of medicine, civil engineering, and meteorology as they were practiced 100 years ago, and, for some, to this day (Kuhn, 1970). Although they were not sciences, they were enormously practiced, disciplined, professional, and useful.

The characterization is neither a critique nor a devalorization, but rather part of a reader's description of how the stats project worked as a design exercise. Nor is it that I imagine instructional design as a field that is pending its fuller development; the argument is not that "ours is a young science." It's not that. The design work here is rigorous and mature by every measure we have for it. The phrase "practical craft" is rather a remark on the task itself, one of designing for and assessing the play of disciplinary knowledge from within fields of social action, in real time.

In my view, the minitool materials and the "data justification" requirements were the heart of the project. They formed the rope on which if the students pulled well enough and hard enough, they would pull themselves into a demonstrable order of mathematical understanding. The exercise was a very good one and thoughtfully executed, and the students pulled pretty well, too. We might even say "they got better at it," which they did.[15] I think we can say that the stats project achieved its design objective in recognizable measures, and if we take this view of it, the success permits us to do something else with the corpus. It opens the possibility of describing what the students did build not on behalf of the design's assessment, but with an interest in the informal logics and grammars of action that the students enacted, as a kind of praxiological solution to the puzzle of learning what they did not know.

The risk of my reading, and only one of them, is that I could be heard as saying that the world, at least for schoolchildren, is this vernacular place of practical orientations and ordinary familiarities, and only that—a kind of "come as you are, leave as you came" exercise. Instead, I am pointing to something like an alternative "genealogy" of classroom mathematical practice. The foundations of classroom math, meaning its foundations for those who do not yet know it, will relentlessly return us to ordinary worlds of practical action. Mathematics is real enough, complete with its professional communities, arcane knowledge, and extraordinary achievements. Formal, disciplinary mathematics is itself a valued artifact. However, I don't think math comes from math, and I do think its first analysis is obliged to begin elsewhere, in organizations of competent practice to practical tasks and even on the "surfaces" of those tasks.

The irony of this commentary is that for all of its appreciation of the articles' close attention to the developing discursive–interactional detail of the recorded scenes, and the collective commitment to ground our analyses in the material detail of what, indeed, the students and teacher were doing, it comes down to a question of how we shall speak of these very things.

It is on this point, which is perhaps the earliest point we can imagine, that I tend to disagree with much in the collected analyses. The greater order, in my view, more robust, recurrent, extensive, and reproducible, *is* the actionable order of classroom lessons. That we find from those encounters the possibilities of such lovely things as math and science is a very nice puzzle to tease out. We may have a very nice place to look for it in the stats project class materials. My commentary is all to the point of suggesting a different place to begin our looking.

REFERENCES

Anderson, C., & Smith, E. (1987). Teaching science. In V. Richardson-Koehler (Ed.), *Educators' handbook: A research perspective* (pp. 84–111). New York: Longman.

Atkinson, P., & Delamont, S. (1977). Mock-ups and cock-ups: The stage management of guided discovery instruction. In P. Woods (Ed.), *School experience: Explorations in the sociology of education* (pp. 87–108). New York: St. Martin's Press.

[15]"Getting better at it" is a delicate thing, too. See discussions of "resistance to change" in the conceptual change literature (cf. Anderson & Smith, 1987; diSessa, 1982; Kuhn, 1989). Getting better at a task might be understood as something more local and contingent than what we normally think of as cognitive development.

Billig, M. (1999). Whose terms? Whose ordinariness? Rhetoric and ideaology in conversation analysis. *Discourse & Society*, *10*, 543–558.

Bloor, D. (1976). *Knowledge and social imagery*. London: Routledge & Kegan Paul.

Cobb, P. (2002/this issue). Reasoning with tools and inscriptions. *The Journal of the Learning Sciences*, *11*, pp. 187–215.

Collins, H. (1985) *Changing order: Replication and induction in scientific practice*. Beverly Hills, CA: Sage.

diSessa, A. (1982). Unlearning Aristotelian physics: A study of knowledge-based learning. *Cognitive Science, 6,* 3775.

Forman, E. A., & Ansell, E. (2002/this issue). Orchestrating the multiple voices and inscriptions of a mathematics classroom. *The Journal of the Learning Sciences*, *11*, 251–274.

Garfinkel, H. (1967). *Studies in ethnomethodology*. Englewood Cliffs, NJ: Prentice Hall.

Goodwin, C. (1994). Professional vision. *American Anthropologist, 96,* 606–633.

Knorr-Cetina, K., & Mulkay, M. (1983). *Science observed: Perspectives on the social study of science*. London: Sage.

Krummheuer, G. (1995). The ethnography of argumentation. In P. Cobb & H. Bauersfeld (Eds.), *The emergence of mathematical meaning: Interaction in classroom cultures* (pp. 229–270). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Kuhn, D. (1989). Children and adults as intuitive scientists. *Psychological Review, 96,* 674–689.

Kuhn, T. (1970). Logic of discovery or psychology of research? In L. Lakatos & A. Musgrave (Eds.), *Criticism and the growth of knowledge* (pp. 1–23). New York: Cambridge University Press.

Latour, B. (1986). Visualization and cognition: Thinking with eyes and hands. *Knowledge and Society: Studies in the Sociology of Culture Past and Present, 6,* 1–40.

Latour, B. (1987). *Science in action*. Cambridge, MA: Harvard University Press.

Latour, B. (1990). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific practice* (pp. 19–68). Cambridge, MA: MIT Press.

Latour, B., & Woolgar, S. (1986). *Laboratory life* (2nd ed.). Princeton, NJ: Princeton University Press.

Lave, J., & Wenger, E. (1991). *Situated learning*. Cambridge, England: Cambridge University Press.

Livingston, E. (1987). *Making sense of ethnomethodology*. London: Routledge & Kegan Paul.

Lynch, M. (1985). *Art and artifact in laboratory science*. London: Routledge & Kegan Paul.

Lynch, M. (1991). Laboratory space and the technological complex: An investigation of topical contextures. *Science in Context, 4,* 51–78.

Lynch, M. (1993). *Scientific practice and ordinary action*. Cambridge, England: Cambridge University Press.

Lynch, M., & Macbeth, D. (1998). Demonstrating physics lessons. In J. Greeno & S. Goldman (Eds.), *Thinking practices in mathematics and science learning* (pp. 269–298). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Macbeth, D. (1996). The discovery of situated worlds: Analytic commitments, or moral orders? *Human Studies, 19,* 267–287.

Macbeth, D. (2000). Classrooms as installations. In S. Hester & D. Francis (Eds.), *The local education order* (pp. 21–72). Amsterdam: John Benjamins.

McClain, K. (2002/this issue). Appendix: The object and the context: What our data are and where they come from. *The Journal of the Learning Sciences*, *11*, 163–185.

Pickering, A. (1992). *Science as practice and culture*. Chicago: University of Chicago Press.

Popper, K. (1959). *The logic of scientific discovery*. New York: Harper & Row.

Quine, W. V. O. (1964). *From a logical point of view* (2nd ed.). Cambridge, MA: Harvard University Press.

Rogoff, B. (1990). *Apprenticeship in thinking*. New York: Oxford University Press.

Roth, W. M., & McGinn, M. (1998). Inscriptions: Toward a theory of representing as social practice. *Review of Educational Research, 68,* 35–59.

Saxe, G. (2002/this issue). Children's developing mathematics in collective practices: A framework for analysis. *The Journal of the Learning Sciences*, *11*, 275–300.
Schegloff, E. (1999). 'Schegloff's texts' as Billig's data: A critical reply. *Discourse & Society*, *10*, 558–57