This paper and commentary is about cultural forms, how agency is frozen into and circulates through them over historical time, and how these processes are relevant for design-oriented studies of classroom learning and teaching. Becker, writing about the costs of being an innovator in the classical music business, frames a lone innovator (Harry Partch, a creator of micro-tonal compositions, instruments and performances; see http://www.harrypartch.com/), who breaks with the “standard package” of Western classical music and consequently spends a lifetime building instruments and training players to perform his compositions. Lehrer and Schauble, writing about the inventions of mid-Western 5th graders conducting experiments with “fast plants” (a past-time invention in the genetics of disease resistant agricultural plants; see http://www.fastplants.org/), frame a group of self-directed classroom investigators, who search for representations of plant growth that are mathematically precise and easy to communicate with their peers.
Chapter 22
Cultural Forms, Agency, and the Discovery of Invention in Classroom Research on Learning and Teaching

Rogers Hall

You can do anything you like, but the cost is high. The more you want to depart from the standard package, the more you find that everything else connected with making music [statistics] has gotten more complicated and difficult. You will have to recruit and train people who otherwise would have been ready to go, you will have to learn new ways of doing things, you will have to construct machinery or adapt it to your purposes instead of being able to use off-the-shelf products. All of that will eat into the time and resources you might have devoted to making art [statistics], which is what you set out to do.


Rather than first presenting students with representational conventions and rules about how to use them, we encouraged students to invent their own representational conventions and then to evaluate the resulting displays against their evolving criteria for communicability and mathematical precision

(Lehrer & Schauble, 2004, p. 669)

This paper and commentary is about cultural forms, how agency is frozen into and circulates through them over historical time, and how these processes are relevant for design-oriented studies of classroom learning and teaching. Becker, writing about the costs of being an innovator in the classical music business, frames a lone innovator (Harry Partch, a creator of micro-tonal compositions, instruments and performances; see http://www.harrypartch.com/), who breaks with the “standard package” of Western classical music and consequently spends a lifetime building instruments and training players to perform his compositions. Lehrer and Schauble, writing about the inventions of mid-Western 5th graders conducting experiments with “fast plants” (a past-time invention in the genetics of disease

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resistant agricultural plants; see http://www.fastplants.org/), frame a group of self-directed classroom investigators, who search for representations of plant growth that are mathematically precise and easy to communicate with their peers.

These are radically different ways of thinking about how the work of innovation—the invention and stabilization of cultural forms—is assigned to people and things over time. In Becker’s treatment, Partch and his followers’ inventions lead to a lifelong struggle against (or around) Western conventions. In Lehrer and Schauble’s treatment, 20 or so 5th graders manage to invent workable statistical displays over a period of a few weeks.¹ For Becker, the standard “package” (p. 304) of making (and listening to) Western music are massive (Akrich, 1992) – there are many people and many productions, bound together in mutually accountable relations of authoring, performing, and listening—and this mass presents substantial inertia to anyone hoping to make music differently. For Lehrer and Schauble, the scale and timeline of inventing statistical displays are comparatively lightweight, playing out inside a single classroom, repeatedly, within a single school year. Learning through invention (or innovation) is a relatively recent discovery in the learning sciences (more on this later), but it is a long-standing problem in the sociology of science. If in Becker’s account, Partch were to succeed at scale, or if in Lehrer and Schauble’s account, 5th graders arrive at precise and persuasive statistical displays, their agency would need to be frozen into and then circulate through new cultural forms. The delegation of agency through circulating cultural forms and “invention” as a way to arrange for this in mathematics classrooms are the broad topics of my chapter and commentary.

Across the arc of work that makes up this edited collection, authors have produced diverse answers to the question implied by this corpus of materials—What is this a case of?² Initial analyses by authors of target chapters were updated, after being criticized and extended by commentators. And in this process, corpus materials were indexed and transcribed more fully. As analysts and authors learned more about the social history of instruction in the classroom studied by Lehrer & Schauble (their introduction, Chapter 2, this volume, was one of the last drafts received), what these materials have come to be “a case of” has expanded.

Now at the end of this arc of work, target chapters still take up productively different analytic stances towards the corpus materials: Wertsch & Kazak (this volume) focus on agency built into potential uses of historical tools like graph paper; Greeno (this volume) focuses on how adults position learners to experience different kinds of agency (disciplinary versus conceptual) as they participate in classroom talk; and Clancey (this volume) focuses on how meaningful activity emerges from transactions within ensembles that put people and things into coordination. These are conceptually diverse adventures within a common corpus of classroom video recordings. Although the target papers take us in different analytic directions, each also delivers a directly normative evaluation of where this classroom is headed: Wertsch & Kazak find it unlikely that middle school students will “discover” complex historical forms, like histograms, during short periods of instruction; Greeno finds that adults do most of the work of reconciling students’ ideas towards a desired instructional form (the histogram), so chances for learning with conceptual agency are reduced; Clancey finds that the use of statistical tools (like a histogram) is almost
entirely severed from an actual context of inquiry these tools might serve (growing plants under a planned, experimental contrast).

Each of these authors’ analyses, including their evaluations of the classroom against some normative model of proper instruction, rest on how they have assembled an understanding of the “social history” (Scribner, 1985) of the Lehrer & Schauble research classroom, as an environment for learning and teaching. How do moments of interaction, utterances and the like, fit together to make up activity that is relevant and meaningful, perhaps in different ways, to participants over time? Any author writing in this book faces a similar challenge, so I will begin my commentary by describing my experience with the corpus, across the arc of work that makes up this book. The social history of learning and teaching that I assemble reflects the luxury of writing after the target authors made their initial (and updated) forays into the corpus of recordings, so being able to learn from what they found. My efforts also reflect several years of ongoing conversation with Lehrer & Schauble, in the context of research on learning statistical modeling. I see the classroom documented in their corpus, and rendered differently in each analysis, against my own history of mutual engagement with them on research in other classrooms and workplaces, but with a common focus on what they call “data modeling” (Hall, Lehrer, Lucas, & Schauble, 2004; Hall, Wright, &Wieckert, 2007).

I would like to investigate the larger context within which cultural forms, agency, and ensemble performance are said to constrain and enable meaningful activity and learning. Doing so will lead into the larger activity system of this classroom and the Lehrer & Schauble (henceforth L&S) design experiment. If children can be said to be inventing something, so too are L&S. Their experiment involves moving against what Becker would call the standard package of mathematics and science teaching. And their project is part of a larger social/research movement in the learning sciences that takes a decidedly non-standard approach to these activities.

Some Prospects and Problems for Secondary Analysis of Learning and Teaching in Video Recordings

Before addressing target chapters in more detail, I feel obligated to describe my own experience with the L&S corpus. This volume is an example of an effort to conduct systematic, secondary analysis of a shared set of video recordings of teaching and learning, but there are others. Tim Koschmann (the current editor) organized an earlier effort to conduct multiple analyses of a problem-based learning episode recorded in a medical school (Discourse Processes, 27(2), 1999), in which I participated as an analyst; Kay McClain (Chapter 7, this volume) organized a similar effort around records of her own teaching of elementary school statistics (Journal of the Learning Sciences, 11(2&3), 2002), for which I served as a reviewer. While somewhat more common in linguistics, secondary analyses of corpus materials are still rare in the learning sciences (see McWhinney, 2007, for futuristic proposals to support “collaborative commentary”). All these efforts might trace their roots (but
typically do not) to the Multiple Analysis Project (Grimshaw, 1994), a 20+ year
effort to complete multiple analyses of a doctoral dissertation defense, or earlier
still to an as yet unpublished report, The Natural History of an Interview (NHI;
see McQuown, 1971; Leeds-Hurwitz, 1987), on an effort by a group of interdisci-
plinary scholars to analyze the interactive environment of a psychiatric interview.
In each case, analysts bring different theoretical perspectives to the same empirical
materials, and their findings are interesting individually and by comparison. Given
this prior history, some of which I encountered while finishing this commentary,³ I
opened the corpus of materials with great interest.

The invitation to comment on target papers came with a DVD containing three
folders (Fig. 22.1, left; Days 27, 28, and 29, later renumbered as Days 26, 27, and
28, which I use throughout), each holding a digital video recording of instructional
activities, a notes file, and a series of “Exhibits” or data displays (Day 26, only). For
reasons of software incompatibility, I could view only the first day’s video recording
and part of another (I obtained all three videos and transcript after the workshop),
and I could not view any of the notes or data displays. I was able to read all the
target papers. This was a rocky start for my attempt to navigate in an unfamiliar
corpus of video recordings, but I do not mean to lodge a complaint. Since secondary
analysis has been rare in the learning sciences, there is value in being clear about
the difficulties of carrying one off.

What does it mean to have (or not to have) an index when setting out in a corpus
like this? On the right in Fig. 22.1 is a pair of images from a study of the history
of the Museum of Vertebrate Zoology (MVZ) at UC Berkeley (Griesemer, 1990).
The tags were written by curators in indelible ink, in a format that was standardized
in the early 1900s and is still in use for indexing specimens (skulls, skeletons and
skins) to field notes (far right in Fig. 22.1) about habitat in the museum’s collection.
The MVZ and its collection are a case study in Star & Griesemer’s (1989) widely
influential analysis of how “boundary objects” can be designed to help coordinate
divergent interests of groups in technical and scientific work. In the case of the
MVZ, trappers, philanthropists, curators, and biological researchers were able to
coordinate around the collection, even though none of these groups saw it in the
same way. Even more important for our purposes, Griesemer (1990) points out that
a suitably indexed collection of material specimens and field observations, like those
found in the MVZ, can serve as a “remnant model” for researchers who may bring
different theoretical perspectives to the collection:

“Remnant models,” i.e., material models made from parts of the objects of interest, […] are
robust to some changes of theoretical perspective because they are literally embodiments of
phenomena. If these embodiments are preserved, they may be studied again and again under
different perspectives, […] Changes of theoretical perspective about the nature of species
can be taken into account by pulling the specimens back out of the drawers or off the shelves
and reanalyzing the model in terms of a different set of taxonomic designations. (Griesemer,
1990, pp. 80–82)

The materiality of the specimens, when coordinated with symbolic descriptions,
allows for analysis from different theoretical perspectives. This is the exactly the
promise of a corpus of video recordings,⁴ like those analyzed in this volume, and
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Fig. 22.1 Indexing schemes for “remnant models”
This is also why indexing the materials (video and audio records, documents) to the context in which they were recorded matters enormously. In the case of the MVZ, a specimen without a tag that permits retrieval of a field note is at best "just dead meat" (Star & Griesemer, 1989, p. 401), and more threatening, an object at loose in an otherwise orderly, material model of habitat-species relations in California.

Back to my experience with the meat... Day 26 starts with what appears to be an ordinary middle school classroom. The teacher sets a task for groups of students seated at local tables, but almost immediately, he invites "Rich" to ask a question about how students should organize their data (Excerpt 1: Day 26, 0:00:07, Appendix B). As the video progresses, four adults other than the teacher drift in and out of camera view, asking students questions or sitting at local tables and working directly on the shared task (researchers Rich Lehrer and Leona Schauble appear to lead this activity). At least one other adult (never seen) operates a camera and a boom microphone. The video record is not continuous, both moving from group to group and skipping over segments of activity that are of indeterminate length (i.e., the record is interrupted in real time, jumping ahead in time, at adjacent video frames). In this sense, the video record resembles a "dub tape," in which selections from an original (presumably continuous) recording have been edited together to show something. The video record foregrounds activity of students working at group tables, but this larger backstage of adult production is itself a complex activity system.

While I could not initially read them, the "notes" files (Fig. 22.1, left) are an important contextual resource, critical for understanding the larger backstage, and they build on one another. The first is a set of notes from March 13 (the relation to "day" videos was not clear), written by a graduate student who worked with one student group on the idea that "typical" heights should be found where a large percentage of plants fall in the distribution. This note ends with expectations for the next class meeting, in which students will compare different groups’ accounts of what is typical. The second notes file is a nearly verbatim transcript, made by Leona Schauble (LS) on March 15, that ends with "reflections" on how what students did last year (a "rockets study") did not carry over to the plant growth study. The third file is a review of the unit, written by the teacher, which incorporates observations and transcript (evidently from LS’s notes) across multiple days. These notes make it clear the 3-day corpus comes from a much longer classroom research study, in which the teacher and a team of researchers collaborated intensively, over 2 years, to help children understand data analysis and statistical concepts.

I will have more to say about this classroom research study, as it exemplifies "invention" (pace Becker and Partch) at multiple timescales, but it is important here to point out that the target chapters in this volume, as well as most of the commentaries (including my own) were conducted and written without any further contextual information about the classroom depicted in three, selectively edited video recordings. The target papers, commentaries, and cycles of revision have substantially enhanced all of our understanding of these 3 days. They have also incrementally built up a substantial index or map of what students and adults were doing during classroom events in the video recording. I think of this as an incremental
“mapping” effort, and there were many uncertainties (e.g., determining which displays were authored by which groups, reflecting which individual’s “ideas” or “inventions” during these 3 days). Several months after the Allerton conference, Lehrer & Schauble submitted a journal article (published 7 months later, in 2004) analyzing what students learned about “data modeling” (p. 636) in this plant growth study. In this sense, the context for the collective effort of secondary, multiple, or “collaborative analysis” (McWhinney, 2007) just keeps on coming.

The larger issue concerns the mobility of context (pre-theoretic, as Griesemer would have it for “remnant models”) as it allows secondary analysts to frame questions, to fully understand activity depicted in the corpus, and to arrive at findings that may diverge from what is claimed by primary analysts (in this case, Lehrer & Schauble as providers of corpus materials; henceforth L&S). That the authors of target papers in this volume used the corpus in very different ways may reflect tensions associated with the availability and mobility of context. Wertsch and Kazak (this volume) select two excerpts of group work (from Day 26) to illustrate how cultural artifacts allow us to “say more than we know,” and more important, to get on with joint activity despite very different intentions and levels of understanding. Greeno (this volume) selects multiple strips to exemplify how classrooms provide spaces for authoring “positional identities,” and he then performs an explicit comparison with two other classrooms. Clancey (this volume) effectively inhabits the corpus, initially ranging over 3 days of life in the classroom (including careful attention to people in the margins of the focal activity), and only later returning to the beginning of the fast plant description task with a sense of who the players are and what is to come.

For a secondary analyst, there is a difference between discovering something that is in the corpus and something that is not. In the first case, other analysts or readers might agree or disagree, and everyone can be pleased with the outcome. But when critical, contextual information arrives after secondary analysis is well underway, there can be trouble. Inferences may need to be retracted or revised, and the “descriptive adequacy” (McDermott, Gospodinoff, & Aron, 1978) of accounts given by secondary analysts is always in question. Again, this is not a complaint about the L&S corpus or the activities leading up to this volume, just an effort to make the risks of investing in secondary analysis, for both primary or secondary researcher, visible.

On “Saying More than You Know” and Hearing More than Is Said with Graph Paper

James Wertsch and Sibel Kazak’s target chapter (Chapter 9, this volume) provides an elegant illustration of the role of cultural forms in conversations where people learn. They focus on graph paper as a cultural form that already has a substantial measure of agency “frozen in,” so to speak. To do this, they develop and illustrate what they call the “Vygotsky-Shpet approach.” The idea is that cultural forms provide
constraints and affordances that allow learners to “say more than they know.” At the same time, and by a slight extension of their argument, we should expect these same cultural forms to allow more knowledgeable others (a teacher or researchers, in this corpus) to “hear more than is said” concerning what learners understand as they struggle to solve problems in tasks presented to them by adults.

Wertsch and Kazak’s analysis of frozen agency is elegant, but as other chapters in this volume demonstrate, the classroom environment in which graph paper exercises its powers is productively messier than their analysis suggests. Is this mess just more of the same, in the sense that students could invent statistical displays by unioning together the constraints and affordances of a legion of other cultural forms? Wertsch and Kazak do not rule this out, and desks, chalkboards, wall posters, fast plants, and other artifacts are certainly available for analysis. Or is there structural regularity in the mess that is meaningfully and consequentially more complex (both for participants and analysts, looking in)? Wertsch and Kazak illustrate the operation of already frozen agency for graph paper, and

Wertsch and Kazak do an elegant job of illustrating how the dimensional structure of graph paper supports thinking and talking about how to organize plant height data, using two episodes selected from the first of 3 days in the L&S corpus of classroom video recordings (Day 26). In these episodes, they examine the use of graph paper that was distributed to groups of students with a directive from their teacher to “organize the data in some way” (Excerpt 1, 0:00:07). Data were posted on a large sheet of paper at the front board in an unordered list of “fast plant” heights, measured by students in an ongoing classroom experiment to compare plant growth under different lighting conditions. Students were also asked to find the “typical height” of a fast plant in the list, and to find how “spread out they are” when the plants were taken as a collection.

In the ensuing activity and conversations, Wertsch and Kazak argue, sheets of graph paper play a key role as,

mediational means, or cultural tools that are used at varying levels of dialogic intersubjectivity. (p. XXX (ms p. 1))

By this they mean that graph paper (rectangular, desk-sized sheets of white paper ruled with equal-area squares) both affords and constrains particular meanings when used to order the listed data. Wertsch and Kazak compare data ordering efforts conducted either between students and adults (their first selected episode) or between student peers without adult intervention (second episode).

Their Vygotsky-Shpet approach to semiotic mediation focuses on,

collision and conflict between a sign vehicle, whose meaning tends to abstract and generalize and belongs to an ongoing semiotic community, on the one hand, and the unique, spatiotemporally located intention of the individual, on the other. (p. XXX (ms p. 3))

Wertsch and Kazak appropriate from Vygotsky the idea that word meaning, as a unit of conscious experience, arises when thought is expressed through the cultural form of words. From Shpet, who was one of Vygotsky’s teachers and himself a student of phenomenology, they appropriate the idea that thought, which is relatively
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continuous or seamless as experienced, is “articulated” and so shaped into discrete units by expression in words. Words both selectively abstract from thought and give shape or structure to thought. In just this sense, users of cultural forms (like words or graph paper) can “say more than they know” by expressing their thoughts in shared cultural forms.

But the approach extends beyond individual experience in important ways. Because the potential meanings of a sign form already exist in a semiotic community, use of conventional sign forms in instruction, amounts to a sort of “taming” or “domestication” of novices’ interpretations of the world.

In other words, the use of cultural forms by learners (novices) may fall well below or outside the conventional, skilled use of these forms by knowledgeable participants in the community. Through instruction, specifically conversations with peers and more knowledgeable adults, learners’ uses of cultural forms become more conventional. At the same time, their thinking and consciousness are shaped by meanings that circulate in the community. In this way, thinking is domesticated by the use of cultural forms. Wertsch and Kazak further argue that some forms, are incredibly robust in that they can allow interpretation and understanding at many different levels yet still support the intermental functioning required to move learning and instruction along.

While it is common to think of student–teacher interaction as a zone of proximal development for learners, Wertsch and Kazak remind us that cultural forms like words and graph paper play a similar role in supporting learners and their conversational interactions with teachers.

Wertsch and Kazak discuss still other implications for the development of expertise in collective activity. Within a community, the distribution of conventional skill or expertise can remain uneven, since high levels of performance by a few individuals may be sufficient for collective purposes, without a wide spread in skill or competence among most members of the community (Nardi, 1993). One consequence of this view is that there may be many mundane users, a few relatively skilled users, and a very few makers of cultural forms. As Wertsch and Kazak put it,

Most of us probably speak, calculate, and carry out other semiotic action most of the time without understanding the full power of the sign systems we are employing. In the famous image of Edward Sapir (1921), it is as if we are harnessing a dynamo capable of generating a huge amount of electricity just to power a doorbell. (p. XXX (ms p. 4); Sapir cited in Wertsch and Kazak chapter)

The consequences for learning in this approach are fairly conservative, by my reading. Whatever level of analysis one chooses when employing the Vygotsky-Shpet approach, all paths eventually lead to Rome (conventional statistical displays). In interaction with others and cultural forms, people go along and get along (microgenesis), eventually acquiring a conventionally structured, historically-specific, individual consciousness (ontogenesis). At a collective level of analysis, existing
cultural forms circulate and acquire their users (sociogenesis; see Saxe, 2002). As Wertsch and Kazak put it regarding what might be learned,

the bottom line is that no amount of exploration on the part of novice students will yield the discovery of things like graph paper and histograms. These are historically evolved cultural tools, and the goal of instruction is for students to acquire mastery of them. (p. XXX (ms p. 13])

While the force of things (cultural forms) on thinking and interaction is nicely illustrated, this approach does not describe or explain innovation or discovery of new cultural forms, how they spread, or how collective practices change. Nor does it help us understand why learners might find it engaging to participate in collective activities, particularly where these are designed to domesticate their thinking (i.e., a narrow view of schooling). In the remainder of this section, I hope to extend Wertsch and Kazak’s analysis in these directions.

Since relatively little context was available to Wertsch and Kazak, it is understandable that they would not attend to prior history in this classroom or to the pedagogical design that was in progress before, during, or after 3 days of video clips provided in the L&S corpus. By combining the video record with Lehrer & Schauble’s (2004) fuller report, we can further explore the development of data displays, including the role of graph paper, by looking back and forth along this larger, connected timescale. For example, Wertsch and Kazak notice that the classroom teacher likened the day’s task to a “thing before with rockets,” then offered “Rich” (Rich Lehrer) a speaking turn to ask questions (Excerpt 1: Day 26, 0:00:07, Appendix B). The video record does not include RL’s full response, but as reported in (Lehrer & Schauble, 2004), the majority (19 of 21) of students in this 5th grade classroom participated in a rocket launching experiment the year before. In that classroom design experiment, reported in Petrosino, Lehrer, and Schauble (2003), students were taught to make and read data displays in which observed values were listed within ascending bins or intervals (see Fig. 22.2). By preserving case values, these displays resembled “stem-and-leaf” plots (Tukey, 1977), a term that was used by several students and the teacher in the 5th grade classroom (the corpus of materials for this volume). Conversations between students and adults in this corpus would be understood, certainly by adults and at least some students, in terms of this prior history of instruction.

There is also striking evidence in the video record that graph paper does not act alone, even if one sets aside prior project history. For example, while writing

![Fig. 22.2 A data display showing student measures of the height of a flagpole](image)
questions about typicality and spread on the board, the teacher demonstrates what he means by “spread out” in the gesture sequence shown in Fig. 22.3.

These contrastive gestures may have provided students with (a) an image of the data cases, ordered from low to high, (b and c) a dynamic simulation of center, enacted as a forceful cut in the middle of ordered values, and (d through f) a contrastive simulation of “spread” as a wide or narrow observed range. In this sense, graph paper circulates in a semiotic and historical environment that is already rich with possibilities and expectations (at least on the part of the teacher and researchers). Within the first few minutes of the video record, activities from the prior year were recalled, the teacher dynamically illustrated center and range, and students asked critical questions about the relation of an unordered data list to their prior activities.

On Being Positioned to Learn with Conceptual Agency While Representing Center and Spread

Greeno (this volume) advances a situative perspective on learning, using ideas from Lave and Wenger’s (1991) theory of situated learning (e.g., learning through legitimate peripheral participation in disciplinary practices), and extending these by...
asking how learners are positioned to take different types of agency in representational practices. His analysis uses the corpus to explore opportunities for learning with *conceptual agency*, in which students learn to use representational forms to pursue their own questions (e.g., in the L&S corpus, finding a way to describe a “typical” fast plant, given a varied collection of individual plants). This contrasts with opportunities for learning with *disciplinary or material agency*, in which students learn to recognize and manipulate forms or materials that make up the conventional representational infrastructure of a discipline (e.g., building a histogram from observed data in conventional statistical analysis and modeling). According to Greeno (this volume; see also Boaler & Greeno, 2000; Hall & Greeno, 2008), both conceptual and disciplinary agency are required for learning the practices of a discipline, though traditional instruction typically focuses more on learning with disciplinary or material agency.

As a theoretical project, Greeno seeks to integrate two aspects of learning that are usually treated separately: (1) *systemic* aspects of social interaction and relations between people in classroom activity – how learners’ participation in activity is structured over time, with (2) the *coherence* of information structures that are produced in and circulate through these activities. Greeno proposes that any adequate theory of cognition and learning must deal with learners’ positioning – systemic relations between participants, involving different types of personal agency – and the coherence or meaning of information contributed by individuals and held in common ground. Hoping to step over polarizing assumptions that pit individual against social and information against activity, Greeno argues,

> activity [is] jointly systemic and semantic ‘all the way down,’ so that whatever the size of an event we choose to analyze, the appropriate analysis will include principles of both informational and interpersonal interaction that function at that grain size in order to explain the event. (p. XXX (ms p. 15))

Individuals learn in activity systems where they create and share common ground, get into alignment with others around collective goals, and make contributions by participating in representational practices that are also changing over time.

Greeno compares learning arrangements in the L&S classroom with those found in two other classroom research efforts, both involving middle school students and instructional activities designed by researchers. From these other classrooms, he presents two comparison cases (Whales, Guppies) in which students are positioned to have agency both for problematizing and resolving questions of representational *coherence* (i.e., whether representational forms capture meanings relevant to pursuit of shared goals). The Whales case is analyzed at the level of adopting tasks and accomplishing goals over multiple weeks, while the Guppies case is analyzed at the level of emergent understandings for tasks that last from a few minutes to a single class period. In both, Greeno conjectures there is a “threshold for problematizing” (p. XXX (ms p. 21)) when participants make proposals for representations or strategies, and this threshold is governed by how the participation structure of the surrounding activity sets expectations about the strength of common ground when students take a decision. For example, in participation structures where students
have comparable rights to make contributions and to guide joint activity, strong
grounding would be preferred, so any member of the working group could chal-
lenge a proposal. In contrast, in a more hierarchical participation structure, where
some participants dominate and others follow or are relatively disengaged, even
weak grounding could win the day.

In his analysis of selections from the L&S corpus, Greeno needs to extend his
threshold conjecture to distinguish between how students and adults are positioned
with agency for generating alternative representations, and then also for reconcil-
ing among these alternatives. In the Whales and Guppies cases, Greeno argues
that students had conceptual agency for both generating and reconciling alternative
representations and strategies. But in the L&S corpus, Greeno finds that students
primarily have agency for generating alternative representations (e.g., a case magni-
tude plot versus a histogram), while adults (the teacher and research team) lead
the activity of reconciling which of these forms is most useful for describing a
typical fast plant. As a consequence, Greeno argues, students’ opportunities for
exercising conceptual agency are limited as they learn about statistical analysis
and modeling.

The teacher (and research team) give the task of creating a representation that
shows center and spread, and how this task relates to a plant growing experiment
is never fully explained. The combined data list may erase classroom history for
some students and even shift the meaning of their prior activities – from multiple
data sheets to a single list, from personal measurements to aggregate data, and from
plant growth to rocket launching. While shifts presented in the new task may be sub-
stantial, they do not appear to be unprecedented. As I understand the L&S corpus,
the history leading up to this task has been carefully arranged, and it is within this
prior classroom history that graph paper circulates, or that alternative representa-
tions are seen as powerful or useful. So in looking back within the available history,
we find evidence of prior cycles of collecting and displaying data with variability.
There is a consistent effort to remind students of this history and to give them clues
about what “typical” and “spread” would look like in a data display they are asked
to make.

Looking forward at where teachers, researchers and students might think this
activity is “headed,” the in progress design experiment involves “inventing” data
displays for common data and questions, then using local work by student groups
to set up a “discussion” (Orsolini & Pontecorvo, 1992). Variation in local work is
harvested to discuss why some displays are better than others for answering specific
questions about “typical plant height” and “how spread out” the data are. In the local
interactions analyzed closely by all the target chapters (Groups 2 and 3, Day 26),
adults play very different roles in helping students use graph paper to create this
prospective variation in displays.

In Group 3, initial work to write data values in separate cells of the graph paper
is interrupted by an adult researcher (LS) and redirected towards creating a “fre-
quency chart” that (as LS puts it) students have used before (Excerpt 4: 0:24:24).
Wertsch and Kazak characterize LS’s conversational moves as an attempt to domes-
ticate or to “rein in the students’ seemingly aimless wandering,” and I was struck by
this image of driving students (like wild horses) towards a conventional statistical display.

There was a time, of course, when graph paper was not yet in wide circulation, and forceful directives were appropriate or even required for its use by otherwise experienced scientists. In a paper on observing stars, written for fellow astronomers in 1833, John Herschel recommends,

Let a sheet of paper be procured, covered with two sets of equidistant lines, crossing each other at right angles, and having every tenth line of each set darker than the rest. By these, the whole surface of the paper will be divided into large squares [...] Such charts may be obtained, neatly engraved; and are so very useful for a great variety of purposes, that every person engaged in astronomical computations, or indeed, in physico-mathematical inquiries of any description, will find his account in keeping a stock of them always at hand. (p. 178; quoted in Brock & Price, 1980)

Returning to the more contemporary directives by LS to students in Group 2, when is enough history enough? As Lehrer and Schauble (2004) tells us, and as LS (then) already knew, these students had been taught to make displays that involved showing the frequency of cases in binned intervals the year before (Fig. 22.2). And as I asked in my original comments at the Allerton conference, “Who here can tell us what are the consequences for being caught doing IRE with children in public?” There was a long silence during which (I inferred) no workshop participant wanted to join LS in the second turn position. Now understood against the prior history of this classroom (i.e., the rocket project, explicit instruction on displays that show the frequency of binned cases), my sympathy for LS has only grown. How could these students, who as 4th graders were able to organize data on the height of rocket launches or a flagpole, now propose to put each plant height value in a separate cell of the blank graph paper?

Wertsch and Kazak also use an excerpt of work by Group 2 to illustrate their Vygotsky-Shpet approach. In this group, early work without adult guidance appears to be moving towards a “case magnitude” display (i.e., values with bars for heights, ordered low to high; Lehrer & Schauble, 2004, p. 648). But as RL’s later questions make clear, students within Group 2 intend to create very different displays (Excerpt 5). One candidate is a case magnitude display ordered by plant names/labels (Jewel); a second is a case magnitude display ordered by plant heights (April and Anneke); and a third is called a “steam and leaf plot” (Wally).

Not only does graph paper (following Wertsch and Kazak, a central mediating resource in this exchange) help students say more than they know, but it also appears that adults can hear more than is said by watching what students do with paper as they speak. As shown in Fig. 22.4, RL asks students to place an arbitrary data value, and their responses show two different approaches to ordering the data collection (i.e., case magnitude displays ordered by plant names/labels or by plant heights).

If graph paper is contributing its semiotic powers in these excerpted conversations, how are these contributions consequential for where the classroom is headed? Comparing these two, local group efforts, it appears that LS and RL have their (evaluative and teaching) eyes on a different “mathematical horizon” (Ball, 1993). LS drives students towards a conventional data display (frequency histogram) that
April (second from left) and Jewel (middle) point (a) at different locations for X, to represent a plant height of 121 mm.

Rich (standing) joined/agreed with April’s point (b) in the middle of the display, as Jewel began to explain, “it depends.”

Rich traced (c) along the x-axis asking, “What’s over here?” Jewel proposed “plant numbers” along the x-axis, with growing dissent from Anneke (left, front) and Wally (right, front).

**Fig. 22.4** RL asked students to explain their display (Excerpt 5)

is part of their prior, shared history (“use your sense”), and she appears to orient towards this group’s finished product (a frequency histogram, under her direction) as the object of instruction (Excerpt 4). In contrast, RL consistently tells students that he does not understand what they are proposing to do, but encourages them to make sure they can answer questions about typicality and spread. When he asks students to try out their display ideas with particular values (e.g., placing 121 in the, as yet, incomplete display), they disagree, and RL encourages them to work independently on their ideas (e.g., Wally pursues a stem and leaf plot on his own). In this sense, RL invites and supports variation in invented displays, which can later
by compared (Excerpt 5). While Greeno points out that RL lends authority to one student’s proposal over another (i.e., Jewel’s proposal to use plant names/labels is discouraged by RL and her peers), students’ thinking is generally oriented towards conversations, later, in which different displays can be compared in terms of how well they answer questions.

It is as if RL has his “eye on the mathematical horizon” of future activity, while LS has her eye on past instructional investment. For RL, the leading question seems to be, “Where is this activity headed?” For LS, it seems to be, “Why aren’t you using what you know?” Pace Greeno’s contribution to this volume, RL positions students to have (and be seen as having) conceptual agency for proposing or problematizing representational displays, while LS (at least in these local exchanges) directs students to remember and use proper disciplinary agency. In this sense, RL’s interactions with students more consistently serve a pedagogy of invention and comparison.

Looking forward in the video record (Days 27 and 28), the kind of variety that RL encouraged locally was realized in five quite different display types. Groups 2 and 3, the focal students in every target chapter, produced almost identical frequency histograms (Lehrer & Schauble, 2004, call these an “Invented display featuring intervals and relative frequency,” p. 654). However, other groups produced displays showing data values as ordered lists, points in a two-dimensional coordinate system, and ordered case magnitudes (i.e., the type of display originally considered but rejected by Group 2, after RL’s leading questions). All these alternatives were made available and discussed, by comparison with frequency histograms, on Days 27 and 28. This process of encouraging local variation in ideas or display strategies that can be used for comparison, later, is in my view a salient structural aspect of where this classroom is headed.

On Playful Aspects of Learning in Ensemble Performance

Clancey (this volume), like Greeno, draws on Lave and Wenger’s (1991) ideas about learning in social practice, but his theoretical proposals are more tightly focused on sense-making as an outcome of coordination between people, cultural artifacts, and arrangements of the physical environment. These shifting forms of coordination yield “ensemble” performances in which people, talk, and action with artifacts create the ongoing environment for each other – a transactional unit of analysis, rather than an interaction between participants and environment:

We analyze a classroom episode as a performance by an ensemble, in which people are improvising, playing over and through each other. Actions are commentaries that promote reconceptualizing (e.g., rechunking and relating) what has transpired (i.e., what are the events of the past) and what the past means going forward. These performances are accomplishments with implicit structure, that constrain individual actions and that [are] sustained and developed by them. (p. XXX (ms p. 42))
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Following an ensemble obligates Clancey to a close analysis of what all participants to an activity are doing, together, over time. It also suggests an open stance, on the part of the analyst, to the relevance or consequentiality of actions as judged by members of the ensemble.¹⁰ Cognition and learning, in Clancey’s approach, come out of the relation between neuropsychological processes linking perception and emotion (inferred from observed behavior in the video record) and patterns of coordination between people. Ongoing coordination has a playful, reflective quality that involves multiply parallel contributions to the sequential coherence (or fragmentation) of group activity and learning. As in Lave’s (1988) earlier analysis of cognition in practice, setting and person shape each other and emerge together.

Clancey’s exploration of the corpus materials is, by my reading, the most comprehensive of all the target chapters. He describes a process of reviewing and making annotations over the entire corpus of video recordings, then he focuses closely on the ensemble formed by Tyler, his student peers, LS as a visiting adult researcher, and the teacher. Clancey’s analysis follows Tyler’s apparently disruptive contributions to early efforts at data organization (with LS; also analyzed by Wertsch and Kazak), then later his central role as a spokesperson for his group when different representations of plant data are explained and compared.

While most analyses of situated learning focus on students’ learning through legitimate peripheral participation in conventional practice, Clancey’s analysis of Tyler’s early (Episode 4) activity documents a process of being involved, playfully, in what might be called “illegitimate central non-participation.” As his group mates struggle to create a representational strategy with guidance from LS, Tyler’s contributions run perpendicular to the group’s apparent trajectory. However, as Clancey points out, Tyler does not leave the group, refuse to answer questions, or fundamentally dis-attend to what LS and his peers are doing. And they do not ostracize him, but play along. When this group later presents a histogram authored by other students, Tyler is positioned to act as their spokesperson, and his contribution to whole class discussion is endorsed enthusiastically by his group mates.

It is important here to be clear about the concept that this ensemble performance brings to the classroom, in addition to how students contribute to its trajectory of development. For example, several important ideas about center and spread were identified in local groups and later brought into the whole class discussion. On Day 27 (Fig. 22.5; see Excerpt 7), in a conversation with Group 3 students (Tyler and peers, the same students working with LS on Day 26), an adult researcher (CH) led them to explore the percentage of cases falling in “center” bins as a measure of whether that range of values was typical. This conversation was conducted over a frequency distribution from Group 2 (students working with RL on Day 26), in preparation for whole class discussion.

Later, during whole class presentation of displays (Excerpt 12), CH reminded Group 3 students of their idea, and Tyler explained their use of percentage in center bins to the teacher. The teacher then showed the entire class how both frequency histograms (produced and exchanged by Groups 2 and 3) supported this way of seeing center (see Fig. 22.6).
Tyler: [Around eleven out of twenty (.)] plants are [(.) in this (category)]
Kendall: [Well: in around that column]
Edith: >I know but didn’t you [say that=]
CH: [Why why do you think [eleven out of]
Tyler: [No we said between (((a)these]

Fig. 22.5 Students in Group 3 work with an adult researcher (CH) (Excerpt 7)

Tyler: So we thought that (1.1) out of these three were the ((a))typical area?
Tyler: That’s what we thought. =
MR: So that’s kinda like somebody came up here the oth- (0.8) yesterday and circled (1.1)
I don’t know who it was. ((MR and Tyler walk to other display))
MR: April I think it was (0.4) said the ((b))typical: Fast Plant Day Nineteen was going to be right around here. Was that you April? [You circled those kind of numbers that group of numbers?]
April: [Yes.

Fig. 22.6 Tyler explains how they used the percentage of cases in center bins as a good estimate of the typical plant height (Excerpt 12)

Similarly, during whole group discussion on Day 28 (Excerpt 9), the teacher asked which display would best show “the spread” if a plant height value of 555 were found (the maximum, observed value was 255). He illustrated how the 2D and line graph displays would show this extreme value (neither used a common scale, so placed 555 adjacent to 255), then a student (Kerri) noted that Group 3’s frequency histogram “leaves the spaces there” when there were no observed values. Evidently seizing on this idea of “spaces,” the teacher then showed how two displays using a common scale (frequency histogram and case magnitude display) would locate 555 very far from any other observed value.
Letting the timeline run over several days, Tyler’s marginally illegitimate, central, non-participation is eventually transformed into delivery (on behalf of his group) of one of the jewels of the entire invention trajectory that L&S have designed: Typical plants would be found in a region that has a sizable proportion of cases near the center. This idea was originally proposed by Tyler, re-voiced and highlighted by an adult researcher (CH) working with his group, and then refined further in local conversation during Day 27 (see Fig. 22.5, this chapter, for the local invention; Fig. 22.6 shows Tyler’s performance on Day 28 as a public spokesperson for the idea). As is clear from L&S’s own analysis of learning in this classroom and the year before (Lehrer & Schauble, 2004; Petrosino, Lehrer, & Schauble, 2003), Tyler speaks for that obscure object of instructional desire these researchers hoped to produce: A multiplicative understanding of data distribution.

I would further argue this is the mathematical horizon that RL, in the turn sequences examined in the prior section, had his eye on during Day 26. It is the culmination of a “discussion” (Orsolini & Pontecorvo, 1992) that is designed and conducted, structurally (as a matter of participation) to invite, collect, compare, and choose among various solutions to a problem of representation (Chapter 19 by Confrey, this volume, makes a similar argument).

The Discovery of Invention in Classroom Research on Learning and Teaching

There is no question that the structure of graph paper was used as a basic resource for ordering data values in this classroom. But the productive use of graph paper is a relatively small part of a broader story unfolding in a classroom already rich with a diverse collection of historical resources, directed towards comparing one type of display with another and deciding which would be most useful for answering questions about the distributional shape of aggregate data. That is, the shifts introduced by the teacher’s opening task (from personal data logs, to an unordered list of collected data values, to blank graph paper) are the start of a developmental trajectory that is being carefully managed in L&S’s classroom design experiment. As this trajectory goes forward, graph paper has its moments, but there is very little that graph paper can tell us about what develops over a longer timescale, or across a broader group of students and their displays.

In this sense, the powers of graph paper in Wertsch and Kazak’s analysis are like weak forces, everywhere available but giving little direction to particular, meaningful human events. The affordances of graph paper make particular sense against a history of prior activity in this classroom (the rocket experiment, instruction on stem and leaf plots, students’ completed plant measurements and data sheets) and the projection of future-time activity in the lesson under development (the teacher’s gestured depiction of center and spread, and an expectation that local displays will circulate in public, comparative talk). Letting the story of this classroom go on a little longer (into Days 27 and 28), we find the variety of displays produced by local
groups, when pitted against the virtues of a frequency histogram (Groups 2 and 3, whether “invented” by students are produced to adult specification), provides a learning environment full of (relatively) strong forces. This is the larger historical project undertaken by the L&S research team, and in which graph paper plays a necessary but not sufficient role.

By restoring parts of this larger project, I do not mean to criticize Wertsch and Kazak’s development of the Vygotsky-Shpet approach so much as to extend it. Their chapter carefully explores how cultural forms shape conversations in which people learn. They use the corpus of video recordings to illustrate the Vygotsky-Shpet approach, not to explain what was happening in the corpus (broadly), the classroom from which the corpus was drawn, or to give a theory of learning that includes invention or conventionalization of cultural forms. Greeno’s analysis, on the other hand, does set out to explain how learning is organized in the corpus, by comparison with two other classroom cases, around the concept of learning with conceptual agency. Students were positioned by the teacher and research team to engage with conceptual agency in generating alternative representational forms (the productive diversity reviewed above), but the activity of reconciling which among these forms was most useful was clearly organized by adults. Clancey’s analysis combines nicely with Greeno’s efforts by following the ensemble performance of a single group over time. Tyler’s playful non-participation early in this ensemble trajectory is tolerated, and his contributions provide the raw materials for developing a proportional meaning of “center” or “typical” by the time his group takes the floor in whole class discussion. All three, target chapters help us trace how concepts are developed and sorted out over the social history of the classroom, but none of these analyses entirely grasp the broader purpose and character of the design experiment in progress within the L&S corpus. This design experiment, as I understand it, is concerned with the invention or conventionalization or representational forms.

I have come to think of this latter, theoretical project as the “discovery of invention” in classroom research on learning and teaching, and it has a history that leads directly to (and through) the L&S corpus. Encouraging local invention for later refinement into conventional cultural forms is a recent discovery by classroom researchers, and I will mention several examples that are similar to what Lehrer and Schauble (2004) describe. One of the most widely cited papers is by diSessa, Hammer, Sherin, and Kolpakowski (1991) with the striking title, “Inventing graphing: Meta-representational expertise in children.” diSessa and colleagues announce,

In November 1989, 8 sixth-grade students in a school in Oakland, California invented graphing as a means of representing motion. Now, of course, we mean that they “reinvented” graphing. In fact, we know that most of them already knew at least something about graphing. But the more we look at the data, the more we are convinced that these children did genuine and important creative work. (p. 117)

Asked to create a representation for a story about travel, students produced a variety of displays that managed time, distance, and speed in different ways (e.g., a “T” display with line segments showing speed and time), and in whole class
discussion, these eventually converged on Cartesian graphing. Subsequent class-
room studies found similar productive variety in students’ invented representations,
leading diSessa (2004) to argue,

It is always tempting to believe only brilliant scientists create really new things, so it
may not seem sensible to bring representational invention into schools. However, it is an
empirical question whether representational innovation and other aspects of MRC [meta-
representational competence] can profitably enter school. Our data resoundingly suggest
that students can productively design new representations, even approaching standard,
scientific ones. In any case, more modest goals might still be extremely valuable. (p. 296)

In a study of 2nd and 3rd grade children asked to represent a model city that
was destroyed and later rebuilt, Enyedy (2005) describes processes through which
“personal inventions” by individual students are appropriated by other students in
whole class discussion, and through continuing debate among alternatives, event-
tually refined into shared representational conventions. For example, faced with
the problem of drawing a “bird’s eye view” of a 3D cone, one student proposed
drawing progressively smaller, concentric circles, while another proposed drawing
perimeter and radius (called a “cartwheel”). After further debate, orchestrated care-
fully by the teacher, a convention for using topographic lines (contour lines) was
adopted by other students and used on subsequent mapping projects. About debate
and refinement, Enyedy (2005) notes,

the change from an invented representation to a cultural convention is not merely an objec-
tive process of selection, but also a social process of co-authorship and transformation.
Given the creativity of multiple individuals, the group as a whole (if it was to act in a coor-
dinated way) had to collectively narrow the field and appropriate only a few of the invented
solutions; in doing so those solutions were elaborated and modified by the group. In this
process, I again highlighted the teacher’s role in orchestrating the discussions that both cre-
ated the desire to have a convention and transformed multiple, personal inventions into a
convention. (pp. 459–460)

Finally, Schwartz and Martin (2004) report experimental evidence that when 9th
grade students are asked to invent statistical procedures before being taught con-
ventional methods (e.g., a measure to represent variation in a sample of data
values), they outperformed peers who were taught the method and asked to practice.
Moreover, students in the “invention” condition were better able to take advantage
of learning resources on later assessments (i.e., invention worked as “preparation
for future learning,” p. 168).

Across all these studies (including Lehrer & Schauble, 2004), the common
discovery is that asking learners to “invent” representations or methods can lead
to productive variety that is useful for comparative discussion, refinement, fur-
ther learning, and development of conventional representational forms. As I think
Wertsch and Kazak correctly argue, discoveries are neither expected nor (most
likely) tolerated on the part of students in classrooms that are strapped for time
and resources. But in the L&S classroom, students are expected and encouraged
to invent, and the variation across their local inventions is an explicitly designed
resource for learning and teaching. This larger activity system is missing in ways
that are consequential for the target chapters, and if included, would strengthen the
analysis delivered by each. Otherwise, this classroom looks like any other, and it is not, if only by force of NSF investment and the sustained presence of a substantial research staff.

Returning to the extended analogy between Partch’s musical inventions and the activities contained in the L&S corpus, it may be more appropriate to pursue the analogy a level up in their classroom design experiment. If the musical score and new instruments are mapped to project-based inquiry units, then L&S are advancing our understanding of how these units can be adopted and implemented in a wider range of public school classrooms. If the musical performers for Partch’s compositions are mapped to public schools (their administrators and teaching staff), the path for adoption and implementation is difficult, particularly given the deep reach of high-stakes testing and federal accountability demands in the US context (e.g., No Child Left Behind). Finally, if Partch’s audience is mapped to parents of school-aged children and educational policy makers, they (like Partch’s audience) need to learn to see this kind of teaching as leading to learning with conceptual understanding, if there is to be a demand for it. As Tyack and Tobin (1994; see also Hall & Greeno, 2008) have argued, the “grammar of schooling” is resistant to change for all these reasons, and the coherence of educational reform has usually involved exactly these challenges.

The discovery of invention may lead to changes in how we teach science and mathematics (as attested in all these studies), but it is not commonplace or conventional in public education, today. And given the polarized political climate of federal educational policy, on the one hand, and calls for an educational science that will clear the shelves of curriculum that have not been shown effective by randomized clinical trials, on the other, they may not become commonplace anytime soon. Creating classrooms that resemble the remnant model offered for analysis by L&S in this volume will be a continuing struggle. Hopefully, the examples of secondary analysis collected here will provide rich resources for that common project.

There seem always to be enough people around to keep things moving a little, enough people with new ideas and the energy to give them a try. The problem about change is not whether there are such people but whether their ideas will be incorporated into the workings of the rest of the package, whether the changes will be institutionalized so as to get the advantage of all the apparatus that is already in place. Alternatively, can innovators create for themselves a new apparatus, which will do all those things the regular system does for older kinds of work? (Becker, pp. 306–307)

Although representations are widely presented, it is far less common for instruction to maintain a consistent and explicit focus on developing students’ capability and propensity to evaluate and compare the communicative value and design trade-offs of a variety of representational conventions. Nor is it standard practice for students to learn to invent new ones for novel purposes. As with variation and distribution, we consider meta-representational competence to be a general form of literacy that has very wide application and that has, in fact, played an influential role throughout the history of human thought (Lehrer & Schauble, 2004, p. 672)

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collaborative work on “data modeling” in middle school classrooms and professional workplaces. I have learned a great deal from them. Finally, I thank Karen Wieckert for continuing conversation about “standard packages” and Chris Ritter for pointing me towards the Brock and Price (1980) article on “squared paper.”

Notes

1. The corpus of video excerpts selected for analysis in this volume comes from only three days of this larger instructional unit.

2. See Ragin and Becker (1992) for a collection of papers on how cases are made, found, or otherwise produced and interpreted in social science research. That one corpus of materials could be used to produce multiple, divergent, but still meaningful accounts of learning and teaching is to be expected.

3. I am grateful to Frederick Erickson for an opportunity to learn more about the NHI project, through a conference he organized to celebrate the 51st anniversary of that group’s work at the Center for Advanced Study in the Behavioral Sciences.

4. Video recording inevitably encodes theoretical perspectives (Hall, 2000), and this must be considered. But good quality video and audio recording are ‘reality close’ in a way that many investigators find more compelling than symbolic description alone (e.g., observational coding, field notes).

5. I have seen Leona go into transcription mode while in a classroom, and it is impressive. The transcripts included as Appendix B to this volume, of course, are much more accurate representations of what was actually said. Following Lehrer and Schauble (2004), I use RL for Rich Lehrer and LS for Leona Schauble.

6. Broader possibilities for learning are considered at the end of Wertsch and Kazak’s paper, where they note that students in these episodes “discovered a great deal of the meaning of these cultural tools through active exploration” (p. XXX [ms p. 27]). They further acknowledge that the Vygotsky-Shpet approach (a variant of cultural historical psychology) and individual constructivism might have complementary strengths.

7. Since my analysis concerns embodied action as well as talk, I use transcript conventions that are slightly different than those adopted in this volume’s common transcript (Appendices A and B). These include creating “toon strips” (Hall, Wright, & Wieckert, 2007; McCloud, 1993) that index by visual juxtaposition and/or number (in single parenthesis) what people are doing with their bodies as talk is produced.

8. It is not possible to know what students noticed or understood about the teacher’s gestures, but he is clearly tracing graphical shapes that are offered as reasonable answers to the questions posed by the data organization task. The semiotic ecology (Enyedy, 2005; Goodwin, 2000) in which graph paper exercises its powers includes talk and embodied mathematical activity that are available for analysis in the corpus.

10. Clancey frames ensemble action, as a unit of analysis, using Dewey and Bartlett, but the practical work of conducting such an analysis is equally indebted to methods of conversation analysis (CA). Like Greeno, and unlike traditional studies in CA, Clancey is explicitly concerned with the informational content of talk-in-interaction.

11. See commentaries and response on the National Mathematics Advisory Panel, in a special issue of Educational Researcher (2008, 37(9)).

References


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### Chapter 22

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