Chapter 15
A Transactional Perspective on the Practice-Based Science of Teaching and Learning

William J. Clancey

Introduction

This chapter presents the perspective of "transactional inquiry" for understanding learning. In my understanding, this perspective is not strictly separable from the other two perspectives discussed in this volume – termed *participation/identity theory* and *dialogic theory*. Rather than being an alternative, the ideas have developed together in many researchers' minds, providing mutual support and value. In particular, I study and understand cognition within an activity theory framework, within which the notion of identity is fundamental (Clancey, 1997, 2006; Lave & Wenger, 1991; Wenger, 1998). For the purpose of this book, I have focused on a transactional perspective, stressing Dewey's notion of *inquiry*, which I have found to be useful in many settings, and aiming to bridge biological, cognitive, and social perspectives on learning. I provide an overview of the transactional/inquiry framework (section "A Biological-Cognitive-Social Framework"), an analysis of three aspects of classroom inquiry (perceptual work, playful attitude and purposeful context; section "Aspects of Inquiry: Perceptual Work, Playful Attitude, and Purposeful Context"), and conclude with a proposed program of studies for practice-based science of teaching and learning, including research questions relevant to the classroom we have analyzed in this volume (section "Conclusion").

A Biological-Cognitive-Social Framework

In simple terms, the analysis presented here is a hypothesis, namely that understanding what happens in human behavior, and specifically where and how learning is occurring, is facilitated by considering the biological aspect of cognition.

W.J. Clancey (✉)
Intelligent Systems Division, Florida Institute for Human & Machine Cognition and NASA Ames Research Center, Moffett Field, CA, USA
e-mail: william.j.clancey@nasa.gov

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More generally, my interest is to use a transactional perspective as an analytic tool to reveal neuropsychological processes (in most respects subconscious) that give cognition its character in different animals and individual people. For example, Damasio (1994) has related emotion to conceptualization in terms of neurobiological processes. I use the term *neuropsychological* to refer to neurobiological processes that cause and constrain the phenomena of perception, categorization, memory, reasoning, and learning traditionally studied by psychologists. A transactional perspective facilitates understanding the structural and temporal nature of neuropsychological processes that affect learning (Clancey [1999] provides many examples). For example, a transactional perspective enables productively investigating humor in the classroom videos (section "Playful Attitude and Humor") by relating neuropsychological and social analyses. This understanding provides a useful perspective for evaluating the quality and effects of the communication between students and teachers in the instructional setting.

In brief, a neuropsychological perspective on learning highlights (at least) the following aspects of cognition:

- *The perceptual-motor system* is not input and output to cognitive processes, but organizes and is organized by conceptualization, in a manner that is always simultaneous (a coupling mechanism), as well a sequential in behavior/experience over time (Dewey's [1938] view of *inquiry*).
- *The affective (self-regulatory) processes* by which emotional experience arises is not merely a reaction to a situation, but is part of the orienting mechanism for sense-making, a kind of pre-conceptual organizer (Bartlett's [1932] view of *remembering*).
- *Structural aspects of conceptual systems* (e.g., closure, islands, splitting vs. joining, verbal vs. visual preferences) surface in a variety of frequently ignored experiences that have been defined away as "not cognitive" or not functional (e.g., slips, humor, dreaming); I call this mechanism *conceptual coordination* (Clancey, 1999).

In this introduction, I intend to present the transactional perspective well enough to uncover and analyze events in the classroom videos. I present some postulates from Dewey and Bentley's (1949) *Knowing and the Known*, plus a diagram from *Situated Cognition* (Clancey, 1997, Chapter 10: "Transactional Experience"). I focus on Dewey's notion of inquiry, viewed as a kind of transaction, which is useful both to describe what is happening in the classroom we are studying and to prescribe a kind of idealized, project-oriented form of inquiry that might improve the students' experience.

Transactional Defined

In common parlance, a transaction involves some form of give and take. Buying something is perhaps paradigmatic: Two players have dual perspectives, one sells,

the other buys; yet both give and both receive in the exchange of money and goods or services. In computer software, the paradigmatic example is a financial transaction, such as processing a check at a bank. One account is debited, the other credited; two numbers are adjusted. In these examples, an action involves two parties, both of whom must carry out their parts for the transaction to occur. The emphasis is on objects that the players are exchanging.

Another perspective, more common in psychology, focuses on how the players themselves are changed, as in this definition of transaction (Merriam-Webster, 2002):

> **1 a:** an act, process, or instance of transacting **b:** a communicative action or activity involving two parties or things reciprocally affecting or influencing each other.

The change here, the influence, is *conceptual*, in contrast to exchanging physical possessions. In simple terms, Dewey would characterize the financial/database view as an *inter-action* (an action occurring between two parties, as emphasized by the hyphen). In contrast, a transactional view of purchasing, for example, considers how the personal relation of the seller and buyer have been changed: Is the buyer influenced to buy from this agent again? Adopting the inter-action view alone, analyses for automating web services focus on goods, services, and financial instruments, ignoring how the manner in which the transaction occurs influences the customer's loyalty, and indeed, whether they wish to *identify* as being this provider's customer or whether the seller is now more motivated to cater to this clientele (Clancey, 2005).

Within a classroom setting, an inter-actional perspective focuses on players, materials, and processes as more or less given, and investigates what productive exchanges occur: Do students reveal misconceptions? Do they progressively exhibit better skills? Are problems solved efficiently? These are relevant questions, but a transactional perspective examines differently how understandings and actions are developing within the action and hence shaping each other. The subject matter (note the substance metaphor) is not merely presented, exchanged, digested, and tested, but is (potentially) transformed in the understanding of the teachers, as well as the students. Perhaps more simply, the students are not simply presented with a situation that they must then understand, but their understanding of the situation is transformed during the learning experience itself. That is to say, the situation and understanding co-develop; the causal relation is dynamic, involving simultaneous, not only sequential effects.

Garrison (2001) explains the term: "Thinking about 'situation' transactionally reminds us that environment and organism, or context and actor, are methodological distinctions within a single, unified, and *ever-evolving subject matter*" (p. 288, emphasis added). In our analysis of classrooms, this "methodological" aspect is practical, pertaining to our developing interests and interest-oriented construal of events within the emerging analysis. Similarly, the people whose experiences we are analyzing are making their own practical distinctions about "situations, occurrences, and objects" (Dewey & Bentley, 1949) in their own activity. A simplified notion of interaction would place an object or person *in* an environment called "the situation"; the inter-action or transactional perspective emphasizes that situations

are continuously conceived and physically changed by actors *within* their experiences (section "Coupling and Sequential Events" explains this in more detail; see also Burke, 1994, p. 22ff).

Encapsulating the idea of dynamic activity – relating context, objects, and purposes – Dewey offers the very useful term, *inquiry*, which emphasizes that learning is an active, dynamic process of investigating, probing, reformulating, hypothesizing, examining, manipulating, deducing, theorizing, experimenting, and so on:

> Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinant in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole. (Dewey, 1938, p. 108)

Note that inquiry is not a particular kind of activity, but for Dewey a fundamental aspect of all experience of organisms (Burke, 1994, p. 113). For people, inquiry has physiological, cognitive, and social aspects, constituting a general theory of how we "counteract disintegrating influences and thereby maintain [ourselves]" (p. 141). Notably, the theory of inquiry does not presuppose the deliberative character of human problem solving, but rather provides "the basis of a constructive account" of "mental states, beliefs, desires, consciousness, [and] cognition" (p. 141). That is, inquiry explains how deliberative problem solving – involving descriptive formulations and inferences – develops and especially its non-deliberative physical, perceptual, and conceptual aspects.

Using the online service example, the transactional perspective suggests viewing the customer's conversation with a travel agent as a process of inquiry. For example, a traveler may be planning a vacation and trying to determine what pleasing destinations are affordable. The character of the *problematic situation* (where to go, when and how?) changes as the traveler discovers concerns or opportunities that arise through availability, timing, enabled activities, and cost. A good travel service focuses not on making reservations, but on planning a well-formed journey by helping the traveler articulate and relate objectives and preferences. Indeed, a problem with today's online tools is that they are designed for a business transaction in the most limited sense, and not for carrying out a collaborative inquiry, through which both producer and consumer would learn and develop a relationship (Clancey, 2005).

Readers of Dewey will recognize the relevance of a travel planning analogy, for Dewey's point about classroom inquiry was that the curriculum was just a map, a tool, not a destination (e.g., see Hall, 1996). As an inventory of organized materials it serves as an *instrument*, promoting conversation in which learning on this and related topics will occur. The ordering and emphasis will depend on the circumstantial dynamics of the classroom. A question of interest is, to what extent is a particular classroom engaged in inquiry like the idealized travel planner I have described? Do teacher and student co-construct the students' goals and interests as they discover together what the course materials afford?[1]

An inquiry itself, my analysis of the classroom represents what interests me today, looking at this material. Reflecting on my own methods, I show in section

"Aspects of Inquiry: Perceptual Work, Playful Attitude, and Purposeful Context" how inquiry might have occurred differently in the classroom we are studying.

Inter-action vs. Transaction

In contrasting inter-action and transaction, Dewey and Bentley (1949) were inspired by 1940s biological studies of the cell: "Manifestly, the subject-matter of behavioral inquiries involves organism and environment objects jointly at every instant of their occurrence, and in every position of space they occupy" (p. 130). They claim that the setting is always inherently "transactionally organic-environmental," so we must beware of the danger of specialized investigations that separate the system into parts to be understood independently, which they list as the mind, the psyche, the person, and the neural center.

Dewey and Bentley emphasize that an inter-actional perspective is based on interacting properties of predetermined (atomic) entities. Thus inter-action concerns how traits interact, giving rise to observed properties, rather than how behaviors are improvised, emergent, and dynamic within a developing situation (affected by the person's manipulative probes and tentative actions):

> [The transaction perspective is] inquiry of a type in which existing descriptions of events are accepted only as tentative and preliminary, so that new descriptions of the aspects and phases of events, whether in widened or narrowed form, may freely be made at any and all stages of the inquiry. (p. 122)

> [Inter-action:] the various objects inquired into enter as if adequately named and known prior to the start of inquiry, so that further procedure concerns what results from the action and reaction of given objects upon one another, rather than from the reorganization of the presumptive objects themselves. . .. Transaction. . .proceeds with freedom toward the re-determination and re-naming of the objects comprised in the system. (p. 122)

The subject matter, the "facts," and the perception and conception of context and self interests develop in the activity that is the realization of inquiry:

> Inter-action assumes the organism and its environmental objects to be present as substantially separate existences or forms of existence, prior to their entry into joint investigation. . .. (p. 123)

A transactional approach is wholistic:

> Transaction is the procedure which observes men talking and writing, with their word-behaviors and other representational activities connected with their thing-perceivings and manipulations, and which permits a full treatment, descriptive and functional, of the whole process.. . . (p. 123)

One should avoid the misconception that some human experiences are interactions and others are transactions. Rather, we are invited to view all human experience as transactional, and like any analytic framework, use it as a tool for inquiry. Specifically, where does it lead in developing a practice-based study of learning and education?

One heuristic for adopting the transaction perspective in the present classroom video analysis is to focus on conceptualizations that are not about objects or people in isolation. After becoming familiar with the players, the layout, and the process, we can consider: *Relations* between people, how they are conceiving of their *persona-activity* (who are they being now?), and *norms* they express and enforce. To bring out the neuropsychological aspect of these conceptualizations, I focus on the interplay of perception, emotion, and conception visible in the classroom video (section "Aspects of Inquiry: Perceptual Work, Playful Attitude, and Purposeful Context").

Coupling and Sequential Events

The transactional perspective can be useful for talking about and visualizing the relations between emotion, perception, conception, and action as we study classroom episodes. In particular, my approach to situated cognition has been to emphasize how these aspects of cognition are co-determined (i.e., functionally and physically develop together). The main ideas are summarized here (see Clancey, 1997 for elaboration and references):

- Categorization occurs on two levels of neural organization: perceptual and conceptual.
- Conceptual categorization is higher-order (composed of other categorizations hierarchically and serially) and always temporal (either sequential or simultaneous, aka *structural coupling*).
- Categorizations are constructed (develop) from previous categorizations; thus categorizing is in some respects an activation process.
- Perceptual categorizations relate features, which are themselves not given, but learned.
- Information is not given (substance entering the organism, an input), but categorizations forming within actions.
- Perception, conception, emotion, and action are mutually constraining, i.e., they arise together, co-develop, determine each other.
- Conceptualization of context (my situation now) and activity (what I am doing now) are mutually constraining.
- "Seeing as" and figure/ground transformations are fundamental to visual conceptualization.
- Describing occurs in conscious (speaking, writing, silent speech) behavior, not internally as (timeless, subconscious) inferences between actions.
- Descriptions (most generally, models of the world) are instruments within an inquiry activity.
- Descriptions do not act on descriptions in the human brain, in the manner of a logic calculus; descriptions are perceived, reconceived (interpreted), and reformulated through new conceptions – the activity of comprehension is not text manipulation but conceptual re-coordination.

- Deliberating is an inherently conscious activity occurring within inquiry, as sequences of representing (in imagination or the shared world) and reflective comprehension and reconsideration – not occurring subconsciously between thoughts.

Summarizing from Dewey's perspective, thoughts provide the materials for inquiry, they are neither its atomic elements nor its molecular products: "Perceptual and conceptual materials are instituted in functional correlativity with each other, in such a manner that the former locates and describes the problem while the latter represents a possible method of solution" (Dewey, 1938, p. 111). The reciprocal relation of perception and conception develops within and influences inquiry:

> Both are determinations in and by inquiry of the original problematic situation whose pervasive quality controls their institution and their contents. . . As distinctions they represent logical divisions of labor. . . The idea or meaning when developed in discourse directs the activities which, when executed, provide needed evidential material. (p. 111–112)

In my understanding of inquiry, I have also reformulated Schön's (1979, 1987) analysis, itself adapted from Dewey, to fit terminology more commonly used in cognitive science. I believe this framework is a practical starting point for applying a transactional perspective in the classroom, which is to say, to study learning as inquiry:

> Schön's framework requires a shift in perspective: We view descriptions as *created in conscious behavior* – in imagining, speaking, writing, drawing, not manipulated in a hidden, cognitively impenetrable way inside the brain. In its primary manifestation, human memory is the capacity for automatically composing processes of perceiving and behaving, including creating representations (doing, adapting). In cycles of such behavior, what James called the "secondary" aspect of remembering, we *model* what we have said and done before (framing, history-telling) and engage in a meta-activity of modifying our language, tools, facilities, and social organizations (designing). (Clancey, 1997, p. 217)

I visualize these phases – doing, adapting, framing, history-telling, and designing – as iterative and simultaneous (conceptualizations occurring at the same time and influencing each other). Figure 15.1 shows behavior as cycles of perception-action of two people, with different levels of transactional influences. The key idea is that

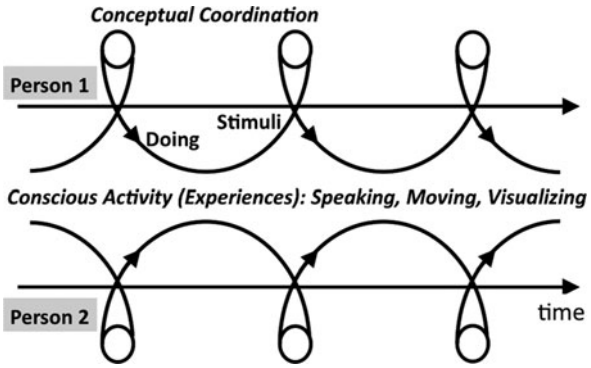

Fig. 15.1 Transaction involving two people

speaking, visualizing, and transforming things in the world occur *over time, as activities,* involving both neuropsychological and interpersonal coordination (Clancey, 1997, pp. 218–219).

The essence of "transactional" is to view stimuli, intent, visualizations, etc. as both reorganizations of experience (present and perhaps distant past) and orientations for the current activity (which involves perhaps simultaneously speaking, drawing, and visualizing). Thus, contrasting with models of problem solving in which a problem is claimed to be given to a subject, the causal relation between problem, inquiry, and resolution is non-linear. Rather than "stimuli causes response" or "emotion is a reaction to a situation" or "conception interprets a perception," we have responses that change stimuli by movement, emotions that orient our conception of what the situation is, and conceptions that change what objects or relations are perceived. In saying "determinants in and by inquiry" Dewey emphasizes that the causal relation is both simultaneous and sequential, represented by the circles and loops in Fig. 15.1. We might look for such temporal relationships in the classroom video.

Nobody contests that learning involves neurological processes; the question is how is the biological nature of learning manifested in a classroom? I show in section "Aspects of Inquiry: Perceptual Work, Playful Attitude, and Purposeful Context" that neuropsychological constraints and influences are especially salient in the perceptual work of creating and interpreting graphs and the humorous interplays of the class sessions we are analyzing.

A Meta-Methodological Reflection

In summary, the essence of a transactional perspective is to beware carving up the world into objects with properties and then studying them alone or in interaction. Accordingly, there is no one way to break up the whole system to define "the transaction." In particular, my own analyses are contingent constructions: I have made selections from the video for a variety of reasons, including the time available to me, what I believe to be of interest to the research community, my past experience in analyzing classroom videos, what engages me today as dramatically interesting, what the camera position reveals, and so on. I have been charged with presenting a particular perspective, so I don't focus on identity, participation, discourse, etc. I am presenting materials that in some important sense do not pre-exist my analysis, in the sense that they are carefully arranged selections; laden with my own emotional manner of ordering my life into a world of objects, people, and relationships; and described in a rhetorical fashion in the genre of a presentation and analysis that must include new findings and recommendations.

It is not my purpose to do a meta-analysis of the methodology of studies of learning, but to present a particular perspective that embodies such a methodology. Dewey states this aptly:[2]

> Selective emphasis, choice, is inevitable whenever reflection occurs. This is not an evil. Deception comes only when the presence and operation of choice is concealed, disguised,

> denied . . . Whatever enters into choice, determining its need and giving it guidance, an empirical method frankly indicates what it is for; and the fact of choice, with its workings and consequences, an empirical method points out with equal openness. (Dewey, 1958, p. 34)

In particular, I may sometimes appear to be adopting a folk view of research, as I put forward excerpts and interpretations as if they are objective facts that preexisted my interest and are unchanged by my thinking, writing, and working with others on this project. But this apparent unwittingness may itself reflect how neuropsychological constraints affect analytic practice.

Referring back to the logic of inquiry paraphrased from Schön, it appears reasonable to hypothesize that the sequential and compositional nature of categorization affects how we order experience into objectified things, sequential stories, and linear causal models (Clancey, 1999). Were I to self-consciously apply the transactional perspective to critically examine my own analysis as it unfolds, I might stumble over myself, and be ineffective, precisely because as I approach these materials I need to chunk, label, order, sequence, and causally rationalize in a certain way – because that is how the simultaneous, parallel aspects of activity are discretely and serially realized in personal experience, in stories, and in our research communications.[3] Although the initial style is deliberately narrative, we can later adopt a transactional perspective to better understand how the inquiry developed: "Transaction. . .represents that late level in inquiry in which observation and presentation could be carried on without attribution of the aspects and phases of action to independent self-actors, or to independently inter-acting elements or relations" (Dewey & Bentley, 1949, p. 121).

Further, my reflection on methodology suggests that the transactional perspective may be difficult for the classroom participants to grasp. The ideas of coupling and dynamics may not have any apparent value at first, because they require an understanding of problems and solutions that is not simply packaged into procedures. Teachers may prefer and even require linear causal explanations and methods if they are to gain anything from our study: Here are the parts, here is how you put them together. And at a certain level, this restriction may carry over into the genre of our research writings and workshop presentations.

Aspects of Inquiry: Perceptual Work, Playful Attitude, and Purposeful Context

Before writing the analysis that appears in this section, after several days of reviewing the materials I annotated the two available segments with what I call "Tyler's group" (including Jasmine, Edith, and Kendall). The first is on Day 26, as they design the graph with LS. The second is on Day 28, as they present another group's graph and comment on their own. I then summarized patterns that interested me: Most strikingly, the graphs vary more than I would expect in a classroom exercise. The class converses at some length about the graphs, both with and without

teacher direction. The students clearly make sense of the markings, learning why graphs have keys and thus that they may have different designs. The students also explain graphs by attributing beliefs to the designers, recognizing that different groups understand and think in different ways ("To them ours didn't make sense, and to us theirs didn't make sense" [Excerpt 9, 0:09:35]). Contrasted with using conventional textbook designs, the students' graphs provide interesting material for the class to investigate.

On the other hand, based on fidgeting and how often many students appear bored, something appears wrong in how the exercise is designed or being carried out. Further, the teacher's enthusiasm for each graph made me confused about the measure of value; is this a brainstorming exercise where creative variation is highly valued?

With many possible interesting topics to explore, I have chosen to elaborate three themes from a transactional perspective:

1. *Perceptual Work: Putting out representations into shared space.* The graphs are representations that are manipulated, re-perceived, reinterpreted, and adapted in design and presentation activities. But the teacher's virtual modifications of the graphs reveal that imaginary objects may also be shared.
2. *Playful Attitude: What does laughter and play suggest about classroom practice, relevant to designing educational activities and evaluating learning?* The video record enables us to learn a great deal about Tyler's group. Studying the nature of humor in this episode reveals the value of a transactional perspective, specifically in understanding and designing facilitation.
3. *Purposeful Context: The classroom exercise and teacher's lesson plan focuses on math as inherent, abstract properties of graphs, as opposed to framing the graphing within an inquiry about planting.* The confusion about which graph shows "spread" better suggests a problem, which could be explained by the "decontextualization" of the list of numbers (Collins, Brown, & Newman, 1986; Brown, Collins, & Duguid, 1989).

Perceptual Work

Perceptual work is a good example of Dewey's point about the active nature of getting information: Parsing the data chart (called a "graph" in the class), orienting the presentation sheet, understanding graph notation (what's a symbol, what's a design?), relating the graphs to each other. As demonstrated by Schön (1979, 1987) and Bamberger (1991), inquiry often involves constructing representations by perceptually segmenting and manipulating physical objects.

Interpreting Visible Artifacts

The plant data sheet provides an obvious example of perceptual reinterpretation at work. Each word of the title at the top of the sheet is apparently aligned with a

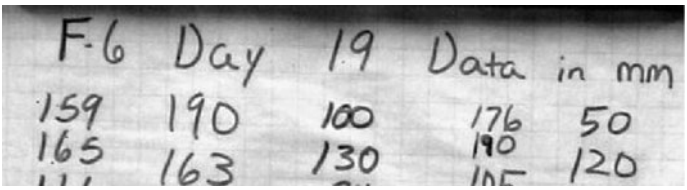

Fig. 15.2 Data chart combining plant heights measured on Day 19 (Excerpt 1)

column: "F-6 Day 19 Data in mm" (Fig. 15.2). The students picked this up. Debbie says, "I don't get it at the top it says F6 and then day and then 19 and then Data (1.0) and then . . ." [Excerpt 1, 0:02:46]. She later re-emphasizes that she is attempting to interpret the first row, "So the numbers under Day are really from F6 and high lighting?" [0:03:16]. At this point, the teacher realizes how she is viewing the table, "Are you thinking these are column headings?" [0:03:27]. This reveals that Debbie is following the convention for perceptually grouping a chart into columns with headers. The teacher segments the diagram by drawing a line straight across the first row, signifying that it is a caption: "It's just F6 and high lights from Day 19 in millimeters" [0:03:31–0:03:39]. He then asks whether Debbie now "understands what she is looking at" [0:03:45].

Another problem is that the 190 below Day might be read as 110 (perhaps explaining Tyler's remark [Excerpt 12, 50:17] that they had one too many 110s). Further, the chart is said to combine data from two experiments, but HL is missing from the title – further implying perhaps that F-6 designates the column with data from that particular experiment. (Indeed, for all we know, this was the original meaning, and later the data were combined.)

Another recurrent perceptual transformation is how empty space takes on meaning (Schön, 1979). For example, responding to the teacher's question [Excerpt 9, 0:12:26] about whether it is easy to see in a graph a "lot of spread" in the numbers, Kerri notices that using a coordinate system (scale for X-axis on the bins graph) results in white space where there is no data – and this empty space has meaning:

Excerpt 9 [0:12:48–0:13:07]

0:12:48 Kerri: ⌈⌈*((pointing to Group 3's graph shown in Fig. 2.5))*

0:12:48 Kerri: ⌊⌊Well I think that probably this graph because (.) it lea- they still leave: (0.9) some spaces there, (0.8) in case there would be even though there's not, so that you can (.) really see how spread out it is because it (0.5) goes (0.3) thirties, (0.5) up to the most and you can see if when there's like (0.7) >how much< ⌈space is there between it

Another striking example of perceptual work is how physically turning a representational artifact may lead us to interpret it differently. In attempting to explain another group's graph, Ian says [Excerpt 10, 0:18:50] that "they had the tens column going up the side on the Y axis and then they had the ones digit going down the X axis. . .." The teacher responds [0:19:34], "You would like it if the graph was turned maybe," removes the tape attaching the graph to the chalkboard, and re-tapes the sheet to the board after having it rotated it 90°. He says, ". . .it starts to look more like what another group started getting" [0:20:02]. It is a strange idea, when you consider it, that how we conceive a representation depends on how it is oriented with respect to our eyes.

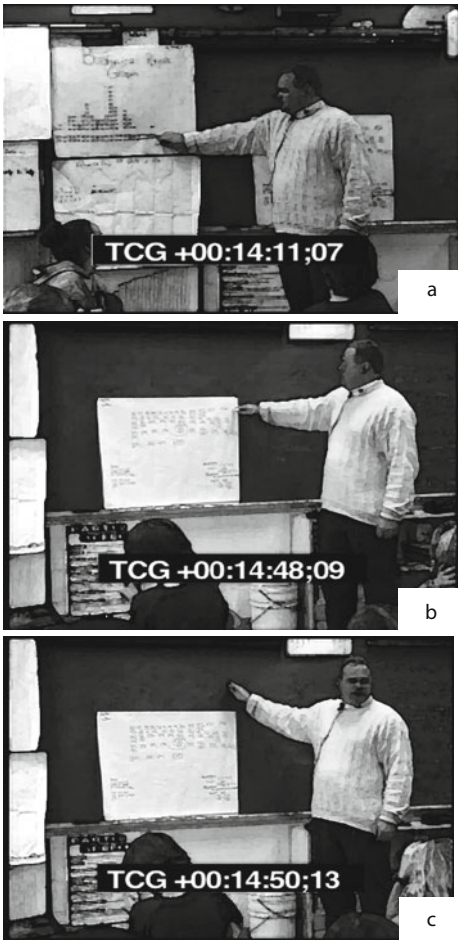

Fig. 15.3 Imagining how to plot a value of 555. (Excerpt 9)

Sharing Imaginary Representations

In the available video, the most interesting example of imagining representations occurs as the teacher leads the group to compare the graphs and imagine extensions to determine which would "show better the spread" [Excerpt 9, 0:10:28–0:17:03] if they ignored the 255 data point and included instead 555. This is all performed visually, covering the number 255 on a graph and writing 555 on the chalkboard (Fig. 15.3c). He asks [0:10:42] if that "feels like it is quite a bit different," opening his hands out with arms wide. With no one apparently disagreeing, he asks [0:11:03], "Would this graph help you see that that's more spread?" Picking up another chart and gesturing, he says [0:11:10], "Let's say we did it, we did to this one, we put 555 right here on the end." He points where one might put 555 on yet another graph, and asks [0:11:26], "Is there a graph up there that would be better to help you see that spread?" After a few minutes of interaction with the students, he summarizes [0:13:51] that "having a scale down here, which is 1, 2, 3, whatever it is, would help you see spread better?" He then checks their understanding of this visualization, gesturing how the X axis could be extended from 250 to 555 [0:14:21], with Wally recognizing [0:14:27] that this would require 31 more entries (250 + 10*31 = 560).

Excerpt 9 [0:14:42–0:14:55]

0:14:42 teacher: Yeah. so we'd have to continue on here to five-hundred and fifty ⌈to five-hundred and fifty,

0:14:44 teacher: ⌊((*extending the x-axis across the board to the right of Group 3's graph*))

0:14:46 student1: Nine.

0:14:47 student2: Nine.

0:14:46 teacher: Ni:ne and then there'd ⌈be a five fifty-five right above it.

0:14:49 teacher: ⌊((*marking a point on the board directly above the projected x-axis*))

0:14:52 teacher: >Then that then that< then that would look pretty spread out, wouldn't it?

Again, they are sketching virtual graphs (e.g., extending out and saying what it would look like). This becomes part of the portfolio of graphs on the board, these imagined extensions. The teacher begins his demonstration (Fig. 15.3a) with the graph designed by Tyler, Edith, Kendall, and Jasmine. He extends the abscissa across the board and eventually onto the tabular representation produced by Janet and Rene (Fig. 15.3b). He then projects a point (Fig. 15.3c) that falls on the board above Janet and Rene's representation. Once again he asks them to describe this imagined chart, "That would look pretty spread out, wouldn't it?" [0:14:52].

He continues to ask them to imagine editing the graphs and imagining what they would look like:

Excerpt 9 [0:15:00–0:15:07]

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0:15:00 teacher:    Whereas on this one, all we'd have to do is,
                    ⌈erase this (0.4) and put a five there (0.3)
                    and we just leave it there right?
0:15:02 teacher:    ⌊((pointing at entry on tabular representation
                    produced by Rene and Janet))
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He concludes by summarizing the result [0:15:15], "And like Ian said, so long as you have a scale on the bottom, I think that helps people determine how spread something is." Then a 45 s conversation occurs with half a dozen players, as the nature of a scale is further emphasized. More imagined objects and functions are constructed:

Excerpt 9 [0:16:40–0:16:56]

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0:16:40 teacher:    Yeah, they could put a scale on
0:16:43 teacher:    So five hundred they get to a ⌈hun- (0.3) what
                    do they got up here two fifty?
0:16:44 teacher:                                  ⌊((pointing to
                    top of y-axis of Kurt and Malcolm's graph with
                    a meter stick))
0:16:46 teacher:    So five hundred would be (.) twice as high.
0:16:50 teacher:    So it's gonna be up there somewhere so would
                    that (.) that scale helps you see will help
                    you see how high it is.
```

The students are clearly following along, as Kristen concludes while pointing to Group 3's bins graph and then the Y-axis graph [0:16:57], "I think that one and *that* one would probably help."

In summary, the meaning of the graphs has now been transformed several times: By the groups working with each other to understand the designs; by the presentation with the class probing; and by the teacher's comparing graphs and extending them. They've created a representational world, an ecology of representations, which now includes graphs as artifacts plus imaginary modifications. These are put out by gesturing; they exist now as numbers and lines in a shared space with agreed properties, which are totally imaginary!

The graphs are no longer viewed as just marks on paper, but tacitly as including other (un-written) numbers, and as having a ruler-like scale that defines an axis. The meaning of the graphs for the students now combines their individual intents in their groups as they designed a graph, with the larger issues raised by seeing other approaches and comparing what you can see and what you can change. The overall activity has taken on some of the transactional characteristics highlighted by Schön (1987) in his analysis of architectural sketching, where there is an interplay

between preconception of a design, an initial sketch, a reinterpretation of (perhaps serendipitous) markings, and an adaptation of the design to better fit aesthetic and practical constraints.

In considering the notion of fixed, pre-determined objects versus those whose character emerges in activity, we might contrast the teacher's view of concepts like "spread," and the students' – do their own graphs take on new features as they discuss spaces, for example, and how to talk about what is typical (e.g., Tyler's arms in the air, as he shows the middle of the graph)? Here I am reminded of Schön's (1979) analysis of the paintbrush inventors, discovering that spaces between bristles are functionally channels for the flow of paint. Thus something that is perceptually ignored as "blank space" or devoid of content becomes a feature with describable properties, in the case of the graphs revealing a pattern in a group of numbers.

Playful Attitude and Humor

In this section I explore the hypothesis that we can understand humorous activity as transactional, in contrast with the idea that something or someone 'being funny' is a *trait* of a story (joke) or person.

"Reflex" vs. Intentional Humor

My objective here is to illustrate the social aspects of humor in this classroom, and perhaps accordingly enrich our understanding of the experience of learning, especially in a group setting. In particular, I suggest that including humor in a theory of conceptualization will better reveal the functional role of emotion and thus how it should enter into a theory of instructional design.

First, I distinguish between "reflex" laughter (and giggles or smiles) and intentional actions, which are willfully humorous or playful. The latter range from putting on a happy face (Jasmine's smile for LS) to Tyler's gestures in the group, and his flight back into the room. I use the term reflex advisedly, to refer to a response not mediated by inference. Although uncontrolled, it is conceptually organized and not to be confused with non-cognitive nervous system behaviors.[4]

A good example of reflex laughter is when the teacher mispronounces "bin." The teacher says [Excerpt 8, 0:28:52], "You put things into a ben" (he gestures piling from above). A weak voice says, "A bin?" [0:29:03]. The teacher spells it, "Bee eye en." [0:29:05] and two students say, "I thought you said *ben*." [0:29:06]. The class laughs [0:29:07] as he corrects his pronunciation. This is a familiar reaction in a group when someone makes a mistake. The laughter seems to relate both to the conceptual breakdown (the difficulty of recognizing the mispronunciation), as well as the social relation (Provine, 2000; Glenn, 2003). The reaction is quick and subconscious. Overall this laughter suggests a good rapport between the teacher and the class, and affirms a norm for handling slips, which are unintentional mistakes in someone presumed to know better. (It would be absurd to lecture the teacher on the difference between the two words; misunderstanding wasn't the nature of the error.)

Another example of a reflex laugh occurs when a girl has read out the average written on a sheet as a number greater than a million:

Excerpt 8 [0:23:21–0:23:36]

```
0:23:21 teacher:                  ⌊Well even if you divide it
                    think about the number does the number make
                    sense?
0:23:26 teacher:    If we added all these numbers up ⌈would we get
                    a million?
0:23:27 student:                                     ⌊No, if you
                    look carefully it's one hundred thirty-three
                    point seven six nineteen.
0:23:34 Janet:      That's a point?
0:23:35 student:    Yes, it is!
```

The laughter that followed may acknowledge that perhaps the mark is an unusual decimal point, making this a self-deprecating response – a way to handle conflict. Later, a student asks about the origin of the "stair graph" design:

Excerpt 11 [0:30:49–0:30:56]

```
0:30:47 student1:   How how did you get your idea for that? =
0:30:49 Michael:    = Yeah. =
0:30:49 student1:   Cuz I mean it's not something that jus pops
                    into your ⌈(.) head like that
0:30:52 student2:             ⌊Heh: heh heh heh.
```

Several students laugh, possibly reacting to the form of the question. Kerri responds that they "were thinking about different graphs, that we could make like bar graphs and stem and leaf . . .." But they didn't like that, so they just "started to think up new ideas that would work and make it" [0:30:56]. A student replies:

Excerpt 11 [0:31:18–0:31:56]

```
0:31:18 student1:   You wanted it to have like it's an original
                    graph? Because I've never seen that one
                    before.
```

Kerri smiles and laughs, acknowledging the apparent compliment. The interaction punctuated by laugher suggests a certain awkwardness from the uncertainty in knowing how to think about the graph's unusual design. It's interesting, but is it good?

In contrast with reflex laughter, joking and playful behavior occur more deliberately (with attentive control), *as a manner of carrying out an activity*, expressing

an attitude that typically persists over several minutes. By the transactional view, a first-order characterization would be that the audience and the humorist co-create the humorous experience or event. Thus Tyler plays to the class, as they anticipate his being funny (and as he anticipates their appreciation). Similarly, the "ben" event starts as a few students' reaction, but becomes more of a class-wide experience as the students hear each other and the teacher responds.

Considering humor is helpful and revealing because it focuses our analysis on behaviors or even better, *experiences*, as the objects of inquiry, rather than only what we normally view as *things*: groups, individuals, graphs, and terms. We also consider attitudes, revealed in an individual's tone of voice, gestures, gaze, and participation. Experiences and attitudes are evident in playful behavior when creating the graphs and in their presentation to the class.

Playful Behavior as Mutually Constructed

We find humor in the classroom video in activities and particular actions, often revealing interpersonal relationships: Jasmine and Tyler repeatedly spar in mocking tones; their group jokes around while making the graph; Tyler evokes laughter several times during the group's presentation. In these activities, the humor involving Tyler suggests a playful attitude. This is most obvious in his group's graphing activity, but also both he and Jasmine make playful full-body gestures at the front of the room. Tyler, at least, seems aware of himself as being visible. He is "presenting-to" not merely reciting or standing. He doesn't merely act, he "acts-for" – he conceives of his activity in relation to an audience. His performance is artistic; he improvises aware of his own presence.

This suggests another useful analytic characterization: The participants' conception of What-I'm-Doing-Now (WIDN, see Clancey, 1999). At times Tyler is evidently showing off, pestering, and flirting. His whistling while LS is speaking to Edith and Jasmine may be interpreted in several ways: He is setting himself apart from "the girls" (LS is helping them; he and Kendall will wait it out); he is also arguably rejecting LS's intervention and apparent control of the group. But to the point, Tyler expresses himself not by explicitly disagreeing or seizing control himself (LS outranks him greatly), not by going away (possibly not an option), and not by totally ignoring them. While appearing to literally wave LS's participation away with his sheet of paper [Excerpt 4, 0:30:59], he also interjects relevant remarks, showing that he is paying attention. His whistling therefore appears more like *counterpoint* to LS than drowning her out, a transactional coupling of behavior.

An inter-actional perspective would say, "Ah, Tyler is a playful boy. He is difficult. Place him into any group and he will be the clown." It may be true that a pattern of sorts will occur, but the *character* of the playfulness, and the manner in which it is disruptive (if at all), is open to change, contingently produced by the actions of the whole assembly. This is why it is helpful to see Tyler during the presentation, where he is obviously engaged and even something of a leader. We see that the class as a whole (apparently) relates to him as humorous (was the teacher smiling?) and he is even self-deprecating.

LS comments in her notes, "The boys do a lot of playing around, especially Tyler, and really need to be pushed to work on the problem." However, she never admonishes them in the segment available to us. LS is pushing only in the sense of orchestrating the entire graphing process. Was this pushing Tyler away from the table? A transactional view asks how LS's behavior and Tyler's were codetermining. Just as we wouldn't say that Tyler is necessarily requiring guidance, we wouldn't say that LS is necessarily over-controlling. Together, they form an *ensemble* (with Jasmine, Edith, and Kendall). The ensemble is improvising their parts, as they are inventing a graph, reflecting on the developing design, their progress, their behaviors, and feelings about each other.

Figure 15.1 is an attempt to visualize how two people are mutually constituting their experience. While doing something (even sitting still), each person is perceiving what the other is doing, noticing especially how the other person conceives of what either has said or done before. Some remarks will perhaps be pivotal, but it is difficult to break this into a linear-sequential give and take. Giving and receiving occurs simultaneously for all players, and is multidimensional. Tyler whistles while LS is orchestrating; at the same time he is paying attention to what they are doing while moving around in a way that distracts the others. Oddly enough, when challenged ("Tyler!") he responds not with something yet more boisterous, but with a productive remark about the work. He is always engaged, as I show below in a more detailed analysis. This conceptual ability to blend multiple activities, being tacitly aware of different threads, allows Tyler and the girls to mix commentary on what is happening, while remaining involved with LS. And thus I stress again that the nature of the activity, as transactional, reflects the neuropsychological nature of conceptualization – a coordination process that is simultaneously compositional (with conceptual blending), sequential, parallel (in creating and relating perceptual features and categories of different modalities), and emotional.

Playing During the Day 26 Design Session

During the design session on Day 26, Jasmine and Edith repeatedly rebuke Tyler with a mixture of smiles and insistence: "Tyler!" "Tyler! Stop it" "Tyler! Get off it" [Excerpt 4, 0:28:21–0:31:23]. Their interventions are short interruptions, which more resemble juggling attention, than shifting context from the work LS is guiding. Tyler is still engaged with them, and their reaction is a means of sustaining this relation, while simultaneously working with LS. The relation is mutual, for Tyler's noises and gestures are perhaps not deliberate disruptions, but a kind of commentary on the on-going LS-orchestrated activity. Tyler is part of this activity, as indeed the activity for Jasmine and Edith becomes a blend of attending to and relating with both LS and Tyler. Put another way, Tyler's playfulness is not necessarily a mark of disengagement, but rather *a way of being part of what is going on.* He has not walked away, he is not attending to anything else. He is observing and oriented toward the graph and the conversation with LS. His behavior is a *playful manner* of participation, a mode or style.[5]

Examination of this episode shows that Tyler engages with LS and demonstrates that he is following along. For example, he appears to team up with LS in speaking to the girls when she is momentarily confused, saying that "they don't listen":

Excerpt 4 [0:24:44–0:25:17]

```
0:24:44 LS:        I'm not making myself very clear, am I?
0:24:45 Jasmine:   Hha ha I don't know what you're talking about
                   actually.
0:24:48 Edith:     But we could, we:=
0:24:49 LS:        Do you get a sense of what I'm talking about,
                   Jasmine?
0:24:50 Edith:     Yeah but
0:24:51 Jasmine:   That's Edith.
0:24:52 LS:        That's Edith ⌈and you're Jasmine?
0:24:53 Tyler:                  ⌊Say it again (.) maybe ⌈they'll
                   follow
0:24:54 Edith:                                          ⌊Hehehe
0:24:54 Jasmine:                                        ⌊Hehehe
0:24:55 Tyler:     Cuz you know they don't listen. So (.) >say it
                   again.<
0:24:58 LS:        Well I wasn't very clear (.) I was thinkin'
                   (.) we certainly don't have two hundred and
                   twenty five numbers across here (.) but if
                   we said let's use a square and put all the
                   ones that go from say thirty tah:: to fifty
                   or sixty and then: every time we see a number
                   we could put an X above it?
```

After the girls say they are following LS, Tyler is quick to agree, and Kendall's remark appears to draw him further into the work:

Excerpt 4 [0:25:58–0:26:20]

```
0:25:58 LS:        ⌊Well that's one way of doing it but I don't
                   know if it makes sense to you guys?
0:26:01 Edith:     It makes sense to me:.
0:26:02 Tyler:     Oh I get it!
0:26:04 Tyler:     So yeah yeah what so
0:26:07            ((Theatrically collapses on table))
0:26:10 Jasmine:   •hhh hahaha
0:26:11 Kendall:   TYLER, okay we have ten:
0:26:13 Tyler:     Like so the ones like (.) you said- you write
                   one through ten?
0:26:18 LS:        Yeah ⌈(           ) like that.
0:26:18 Tyler:          ⌊Like all the ones one through ten you
                   put Xs for?
```

After Jasmine rebukes him [0:28:21], Tyler returns the critical tone:

Excerpt 4 [0:28:19–0:28:30]

```
0:28:19 Edith:     Okay we're gonna go=
0:28:20 Tyler:     =Em:::
0:28:21 Jasmine:   Tyler! Stop it.
0:28:22 Tyler:     OH::! You just wrinkled the
0:28:24            ((Pointing finger at Jasmine, Edith snaps
                   playfully at his finger))
0:28:25 Jasmine:   Ha⌈hahahaha heheha
0:28:25 Edith:       ⌊Hahahahaha
```

They are all laughing visibly. Jasmine is obviously happy and looking at Tyler for several seconds. Kendall is pointing and speaking. They are engaged in one activity.

Tyler also picks up the interaction with LS when Edith is uncertain:

Excerpt 4 [0:28:58–0:29:08]

```
0:28:58 LS:        (I believe that's how much there are)
0:29:00 Edith:     I really: don't' understand this.
0:29:02 LS:        Thirty to thirty-nine.
0:29:05 LS:        Forty ⌈to forty-nine.
0:29:05 Tyler:           ⌊Three forty-nine.
0:29:06 LS:        Fifty to ⌈fifty-nine.
0:29:07 Tyler:              ⌊Fifty-nine.
```

But somehow these serious moments are blended with joking around, as for example when he is clearly being "interruptive" when waving the paper, while (perhaps his view of the situation) LS is speaking to the girls. Jasmine is watching with eyes askance (emphasizing her primary engagement with the teacher). Tyler then plays with his arms behind his back and his head near the table, saying "Whoa" and Jasmine tells him to get up:

Excerpt 4 [0:30:56–0:31:24]

```
0:30:56 LS:        Well yeah, so one thing we could do is we
                   could start doing that. ⌈We could right over
                   here and we could try: (0.6) (        ) one
                   thru- zero through nine, ten through nineteen,
                   >twenty through twenty nine,< Just label them
                   across ↑there.
0:30:59 Tyler:                              ⌊((whistling and
                   vigorously fanning a folded paper in LS's
                   direction))
0:31:11 Jasmine:   Shall we start by (tens)?
```

```
0:31:16 Edith:     No:: because people are going to be looking at
                   it (.) this: way
0:31:23 Tyler:     Whoa whoa whoa
0:31:23 Jasmine:   Tyler! Get off ⌈it.
```

The eye contact and Tyler's antics suggest that his interest is more in relating to the girls than in pursuing the graphing problem. But Edith too is playful in her tone and emphasis as she draws out her remark:

Excerpt 4 [0:31:48–0:31:55]

```
0:31:48 Edith:     =No::::↑↑ we do:n't wa:nt it tha:t wa:y
                   because we don't want it that way.
```

Now Jasmine looks at the camera, then rebukes Tyler, and looks at him smiling. Tyler makes a fooling gesture with Kendall, shaking his head up, down, and around very quickly. Tyler also looks up at the camera. Then, referring to the girls, he says, "Wrinklers!" Soon after, they are all laughing when Edith breaks her pencil.

Excerpt 4 [0:32:14–0:32:21]

```
0:32:14 Kendall:   You guys are crinkling the paper! ((parody
                   voice))
0:32:16 Tyler:     YAH, you're wrinklers!
0:32:18 Edith:     Straighter than you guys did.
0:32:20 Tyler:     NO:::!
```

The rebukes are an expression of defining or enforcing a norm, which includes particularly a constraint not to mess with the paper, which is to be the presentation copy. "Tyler!" [0:32:23] could be interpreted as a comment as well as a call, bringing him in to the work. Again, it could have been different: The girls might have ignored him or indeed LS might have said something to stop him. But the expressions and tone suggest more an appreciation of his play than being disturbed. For indeed, controlling propriety and asserting the norms is mutual and playful, as when Tyler says, "OH::! You just wrinkled the [paper]" [0:28:22].

The rebukes – from both sides – constitute the activity of working with LS and preparing a graph for presentation. Again, these remarks seem to be inherent, not interruptions, but a character of the work activity itself. That is to say, this is how they do their work. This is how they carry out the assigned task. *This is their practice*, relating to each other in playful rebukes and interruptions. Indeed, one might say that the proprieties of the classroom, norms such as not wrinkling the paper and attending to LS have provided a resource for relating to each other. This background becomes a setting for Tyler to play against, for them to express how they feel about each other, to explore and develop these emotions. Thus the gestures and drones are figures that tacitly acknowledge the background of the norms. One might analyze further to inquire about the structure of the play, its phases and transitions as people come in and out of activities.

Transactional figure-ground relations – found at all levels of cognitive activity from perception through conceptual classification to interactive style (Clancey, 1999) – seem to be a fundamental organizing aspect of human experience. The formation of categories through figure-ground relations apparently stems from the physical nature of the neural system. In the next subsection, I attempt to relate these analytic perspectives.

Relating the Biological, Cognitive, and Social Perspectives of Humor

In studying the functional aspects of humor, we are confronted with a phenomenon that obviously has biological, cognitive (conceptual), and social aspects. When researchers have studied learning as knowledge acquisition, it has been too easy to omit anything emotional and at the same time a struggle to relate psychological notions of memory and reasoning to social participation and identity. Humor by contrast is unequivocally emotional and often social; certainly the most salient examples of humor – jokes and comedies – involve at least a person and an audience.

On the other hand, although no one questions that humor has a cognitive aspect, the mental processes have not been very well articulated or formalized in models.[6] By Bartlett's (1932) theory of remembering, we might hypothesize that humor is pre-conceptual, a neuropsychological process for conceiving What-I'm-Doing-Now, with aspects that cannot (at first) be coherently related. Functionally, we could say this is the person's means of relating to an incomprehensible situation. In remembering (Clancey, 1999, Chapter 9), the emotional attitude perhaps provides a basis for reconstructing (re-relating) previously active categories, such as in recalling the events of a story. In joking around, the humorous attitude may be a way of coming to terms with events that are inconsistent with past experience and hence otherwise irreconcilable (by the person's normative conceptual logic for organizing activities).

That is to say, in contrast with a folk view that humor is always a *reaction* to a situation (that has the inherent trait of being humorous), humorous experience may be an expression (action) of a disjuncture, a conceptual dis-coordination, an inability to conceive of what the situation is. By Bartlett's analysis, we must experience *something,* we cannot say with blank faces, "Does not compute." Instead, we chuckle, laugh, or giggle. For Tyler, the idea that "we are doing something all the time" is fully visible. (See Clancey, 1997, Chapter 3 for related discussion.)

What I have provided so far is a neuropsychological sketch of humor; the social aspect is of course no less fundamental. Within an interpersonal activity, humor provides a way of handling conflict, which is to say that as each individual must experience something (handle a breakdown in some way), the group also must move its activity forward. So when the teacher asks Janet whether her graph helps one see how spread out the numbers are [Excerpt 12, 0:57:48], she dips her forehead to the table and everyone laughs. As analyst-observers we should always realize: The behavior could have been different. Janet might have said, "I don't know" or "I don't care." Her action instead could be interpreted as a submission, giving in to

the teacher's instruction. Her attitude is open, she resolves the tension by playfully presenting she has nothing to say.

When the teacher asks Rene where 300 would be on her graph, and adds "if there was a 300" [0:59:36], everyone laughs. Perhaps something is happening off camera? Or the idea of a plant 300 in. tall is absurd? Or they adopt the teacher's remark as a means of resolving the tension of the moment? I do not mean to suggest that interpreting what is funny necessarily involves a simple, unique causal story. Indeed, an interesting hypothesis is that at first different individuals have different takes on what is occurring at a given moment, but most become caught up in the group's laughing, and *this* shared experience then orients the group's ongoing activity.

Purposeful Context: A Math Activity Within a Plant Experiment?

Seeing Tyler joking and listening to the discussion of "spread out," I often wondered how the students and teachers are conceiving of this classroom activity. I have argued that in the small group Tyler is always in the activity of designing the graph, despite appearing to be only fooling around. But are the students ever in the activity of *doing a plant experiment*? Do they understand that the graphs are tools for conducting a broader inquiry?

Talk About Properties of Graphs

After an hour into the third day, the teacher repeatedly asks questions such as, "Would this graph show you better – just the graph – how spread out it is?" [Excerpt 12, 1:00:42]. This entire discussion seemed boring to me. How can we talk about the quality of the graphs without talking about some issue involving plant growth? In the videos available to us, the described properties of the graphs are treated independently of the meaning of the numbers, which seems bizarre, given that the students actually came up with these numbers by measuring plants.

The numbers were first bastardized when the two experiments were clumped on Day 26. The students appeared puzzled. Now they are just manipulating numbers. The idea of creating and comparing and presenting graphs is great, but then the inquiry has been moved from the plant domain – where graphs might provide value because the numbers *have value* – to the graph domain – a list of numbers and a generalized property called "spread out." In my viewing, the teacher gives the impression that "spread out" is of interest for its own sake, and that tools for talking about "spread out" (the graphs) can be evaluated independently of the domain from which the numbers come.

I hasten to add that the teacher has clearly made the graphs into a tool for inquiry, riffing off the many designs to make larger points about representation. My concern is that this evaluative talk makes no reference to a problematic setting in which charting occurs. There is nothing here about what the graphs are revealing about the plants, aside from periodic mention that the numbers are heights. It is fine to abstractly try out different patterns (indeed, researchers analyzing data may explore

charting options in a spreadsheet tool just to see what relations might be revealed). But then you say what you see in the graphs that relates to the phenomenon of interest. What information does the graph provide about plants growing under different conditions or different kinds of plants?

My point is not about "relevance" – that the activity should relate to what the students care about – but about the purpose of graphing as an interpretive technique. The students are being taught an aspect of scientific thinking: Where does constructing such graphs fit into an authentic inquiry?

A comment in the facilitator-teacher notes on Day 28 says "Students didn't carry over a lot from the rockets study last year." This is ironic given that the students are not being encouraged to "carry over" anything about *the plants* either. And if the rocket exercise was handled in a similar way, how could they make sense of these graphs any better? Indeed, with all of the debates about the nature of abstractions (e.g., Clancey, 2001b), one might wonder whether abstractions would transfer better if they were contextualized in the first place.

One graph (see Fig. 2.4), developed by Rene and Janet (Group 5), says, "There are 47 different types of numbers used" and "How spread out are the height? 225" (which they show as the difference between the highest and lowest). Here we find two domains of analysis: properties of numbers and properties of heights. The discussion shows that the inquiry is not about plant heights and growth processes, but about the shapes of graphs. Without a reference for "spread out" there is no evaluative criteria for the difference: Why should it matter how spread out a graph is and whether one graph shows it or not?

Plants do get mentioned, but only with respect to "what's typical," not motivating the question about plant growth that might be answered by understanding variability:

Excerpt 10 [0:20:13–0:20:53]

```
0:20:13 teacher:    What about it helps you guys see that the
                    numbers are (.) spread and that they're uh
0:20:20 Ian:        Well:: =
0:20:20 teacher:    = >What a typical fast plant would be?< =
0:20:22 Kerri:      = Well to see how they're spread you have to
                    look up at the highest one (0.5) and then if
                    they're (0.7) so then like on the highest line
                    (0.8) that would be like (in) the highest
                    (1.0) like the (0.4) highest one and the
                    lowest (0.5) would be down here (0.4) and if
                    there's one along the same line then you just
                    look to see how far out this way it is
0:20:45 Kerri:      So if it (   )
0:20:47 Ian:        Or =
0:20:47 teacher:    = Ca can you guys circle on there where where
                    wherever you guys think a typical Fast Plant
                    is? by looking at the graph?
```

Here the numbers are unmistakably interpreted as representing the height of individual plants and growth rate ("fast plant"). But this is an exception. The classroom exercise focuses on conveying properties of graphs, such as "a bell distribution"; thus it is said that using data from later in the plants' life would produce "a distribution that looks more normal." In contrast, inquiring about the plants, what can we say about these plants on Day 19? How do various types of graphs help us understand the plants? Instead, the activity appears inverted, with the intention that graphing plant data will help us understand a bell curve! The focus is tool-centric as opposed to inquiry-centric. Rather than teaching about the nature of inquiry, the activity is teaching about the nature of graphs. What is the purpose of the exercise: Learning abstract math concepts ("spread out") or learning how to use graphing as a tool for doing science? Accomplishing both would make sense, but how could one omit the "math as tool" perspective?

Abstract Layout Talk vs. Sketching and Showing Each Other

A confounding issue is that the graph paper given to the students is for their final presentation; they can't write on it until they have created a design. Consequently, they perhaps waste time arguing in mid air, rather than sketching and showing design concepts to each other. Put another way, the presentation sheet is not a design tool, it must not be marked until the problem is solved. The problem this causes is painfully evident.

For example on Day 26 (Excerpt 2), they talk about where to start, 0 or 30? Couldn't they have simply started by sketching something and reflected on what it looks like? Kent says smiling, "Yeah but (.) do plants start out at thirty? Or at zero:?" [0:09:36], which is nice grounding in the experiment. But Garrett brings the group back to this set of numbers for D19, which starts at 30, "Well we're not really talking about plants" [0:09:39]. Caleb explains the graph is only about the numbers on the board: "Yes cuz (.) it doesn't make any sense to start at zero number when they're not even up there" [0:09:47]. Kent agrees and says, "But where should we star::t?" [0:09:55] with his stress of "start" and head gesture marking a shift in reference to the big empty space of the sheet. We see many gestures along imaginary axes (would could be trivially sketched) (Fig. 15.4).

Another group with three girls and Will are also gesturing to how to use the paper, what layout, what will fit, etc., all in words. Why don't they draw on another sheet and show a model of what have in mind? Why not use a ruler and show what will fit? Indeed, April says, "Just draw it firs:t" [Excerpt 3, 0:12:54]. Jewel sounds exasperated: "That's what I'm saying!" [0:12:21]. Drawing might avoid all the verbal banter. Yet she and the other students haven't even tried – they keep gesturing and talking, overwhelmed with the given constraints (Anneke: "How many numbers are (.) up there?" [0:11:39]) and possibilities (Anneke: "Could you put sixty three: things across here?" [0:11:41]). The single large blank page appears to have caused their method to get stuck on "planning by talking." The tools provided shape the methods used. The graph sheet is like one big fill-in-the-blank test form. (Interestingly, Edith uses her own notebook in attempting to communicate ideas.)

Kent: = What's your nex::t?
sixty-three((*a*))squares
like this,

Fig. 15.4 Kent gestures to where they should start their graph. (Excerpt 2)

Example of Graphing as a Tool for Inquiry

To illustrate how the transactional aspect of graphing has been lost by viewing the graphs as having objective properties in isolation, I will present my own use of graphs for examining the classroom video.

In my experience, quantitative analysis is an essential part of ethnographic studies (Clancey, 2001a, 2002). In particular, video data can often be fruitfully categorized by activities, participant, location, and duration, leading to patterns that are not perceivable in the sequence of a transcript. For example, consider that some episodes appear to be relatively lengthy conversations between students without the teacher intervening. Also, I have implied that Tyler in some way dominates the graph presentation by his group. What are the frequencies and durations?

Consider the activity of Group 3 (Jasmine, Tyler, Edith, and Kendall) when they stood at the front of the room presenting the graph (see Fig. 2.3) produced by Group 2 (Anneke, Jewel, and April). Figure 15.5 represents their discourse, including the teacher's remarks (in black) and other students' questions or comments (dots and grey). I have chosen to view the episode as six periods[7] in which the students were presenting the graph, responding to the teacher or other students, or in which the teacher was directing (the third segment). In showing the episode in this way, one naturally questions the process by which it was created (you might want to look at the transcript corresponding to these segments to be sure you understand the categorization as representing the participants' understanding and whether you can see the alternation the graph claims).

Now we can view the group's presentation through the graph (Fig. 15.5). For example, we see that presenting the graph occurs twice, during about 3 min, which is about 25% of the total 13 min. This suggests a number of new questions: What affects the change between modes (presenting, responding, directing)? Who speaks with whom (is there a pattern of pairing)? Who speaks the most often? The longest during a turn? Who is relatively quiet? How do other groups compare? The graph presents the data so it can be perceptually grasped, revealing patterns (e.g., Tyler and "other" seem to appear together), leading us to ask numeric questions (e.g., how often is Tyler the one who replies to another student) and then pose new questions

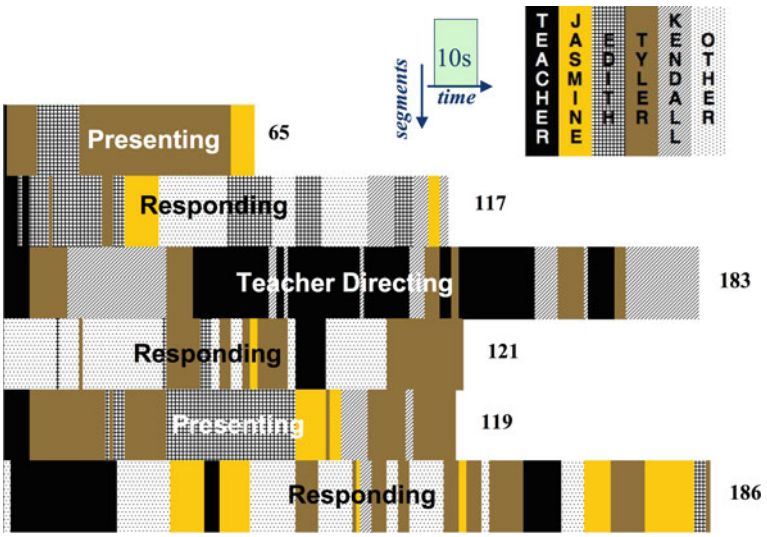

Fig. 15.5 One group's graph presentation (Excerpt 12)

about relations (are the other students directing questions at Tyler or is he jumping in to answer questions?).

Figure 15.5 shows how a graph can be a tool for discovery, as part of an inquiry about the classroom. The graph provides a way to structure the available data, formalizing impressions (e.g. sometimes the teacher appears quiet for long periods) so they can be measured and thus compared. In my experience, creating one graph often leads to wanting another to view the data in another way. Figure 15.6 was an attempt to test my hypothesis that Tyler was speaking most often during the presentation.

The graph surprised me by showing that Kendall spoke more than Jasmine. Before seeing the graph, I would have said that Kendall was relatively quiet. So my impression was wrong. Both researchers and participants can misjudge frequencies and durations of events (Clancey, 2001a, 2006; Clancey, Lee, Cockell, Braham, & Shafto, 2006).

These graphs illustrate the transactional perspective, as applied to teaching and learning, in two critical ways: in creating and sustaining the presentation's structure and in the nature of inquiry using a representational tool.

First, the segmentation suggests a pattern and episodic structure that no one in the classroom is strictly controlling, though they implicitly enable and contribute to its form. Individual behavior is constituted by the pattern (organized by it), just as individuals constitute the pattern (confirming a phase by acting in a way that continues it, e.g., continuing to present the graph while the group is in presenting mode). Thus, the structure of the class's activity and what individuals do is mutual, both influence each other, both in historical form (being influenced by what has come before) and in forward effect (by serving to orient what participants can do next). So I am claiming

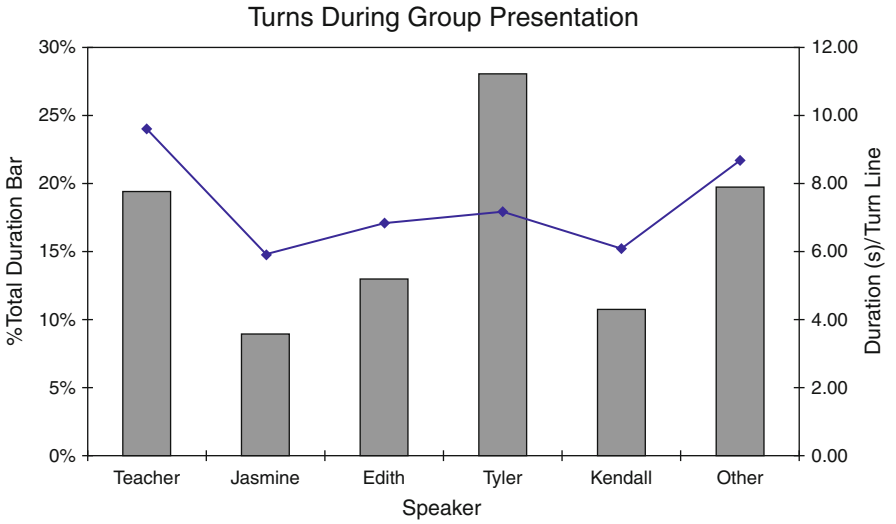

Fig. 15.6 Participant turns during the group presentation

that individuals conceive of the phases (What-We-are-Doing-Now) without naming them, necessarily viewing them consciously as being segments, or being aware of how they are alternating in a conceptually logical way (present-respond-direct-respond-present-respond).[8] However, it is reasonable to conjecture that the teacher is aware of redirecting the activity when he speaks, as I claim a more detailed content analysis would show in the development of the topics being discussed (i.e., I did not simply break the episode where the teacher speaks).

Second, the graph illustrates how representations (whether graphic or verbal) are instruments, as Dewey emphasized, a means for carrying out an investigation. The graphs I present are not my summaries or codifications of "what happened," but my means for transforming the details of the transcript to a visualization with salient perceptual relations, to numeric questions that compare and contrast the individuals and groups, to hypotheses about why events occur when they do, to general conjectures for prescriptive experiments to improve the students' experience – quite a leap to be sure.

The transactional aspect of the graph is realized by not viewing it as a means of presentation of something already understood, already objectified. These graphs are not created to portray the *result* of my inquiry, but are partly hypotheses, partly methods, partly summaries of how far I have gotten in my digging and shuffling and reorganizing of the available data. I use the graphs to convert the data into information through my perception, through computations, and through my poking around to find more patterns and connections. Thus my inquiry is a transactional relation among looking, transcribing, selecting and commenting on excerpts, graphing and inspecting of the graphs, and then going back to reconsider the validity of my segmenting and its application to other groups. My actions in creating and formatting the graphs may be chronologically described, but relate to perceptions

and concepts that have no fixed form. My intention to demonstrate an idea (e.g., showing that Tyler is dominating) produced an artifact with evident patterns that changed the direction of my thinking. And when I present the graph in a new setting, I may interpret its significance differently. My past experience with the graph will partly determine my using it in the future – just as I have imported these figures from my workshop presentation. But when I reuse such artifacts, I may attribute and articulate other values and properties that were only tacit or even non-existent in my original conception, creating a new view of these classroom episodes.

So here lies my ultimate objection to what I see in the classroom video: The graphs are presented as a final product, just as the graph paper was protected from experimentation, so a clean "result" could be put forth. The class is not inquiring about plant biology or agriculture by relating the graphs and asking what other graphs are relevant to an "indeterminate situation" (Dewey, 1938, p. 104). They are myopically talking about the graphs as objects in their own right, removed from a plant-growing activity. Thus ironically, it appears that in this classroom the ideas of invention and presentation have been usefully applied, allowing the students to be creative and giving them the opportunity to address and respond to their classmates directly. But the idea of graphing, which is presumably the curriculum concept, could have been given a much richer scientific or engineering context, and thus conveyed a far more general – and transferable – understanding of how to use graphs to make sense of experience to uncover useful patterns and processes. For example, what is learned about the plants could be related to practical concerns such as lighting and fertilizing plants (e.g., designing greenhouses for Mars).

Correspondingly, I suggest that using graphs to analyze video quantitatively is essential for the scientific study of teaching and learning practices.

Conclusions

What does the transactional perspective, applied to a classroom video, suggest about "a program of studies for practice-based science of teaching and learning"? The research community has generally established that a great deal can be learned by studying classrooms (e.g., see *Journal of the Learning Sciences*). So really the question is focusing on the notion of *practice* and a *program* of studies.

From the perspective of a graph as a tool, the transactional perspective suggests designing learning activities as coherent *inquiry projects* that relate to practical goals. The term "inquiry" emphasizes authenticity – the students must be engaged in an activity that becomes problematic in their experience, as in trying to make something – and not just a chart itself!

A transactional perspective reveals the perceptual work of understanding a representation, and how this may involve rotating the image, distinguishing notations from designs (figure from ground), and imagining transformations (inferring and applying the design). Similarly, we are led to view interpersonal experiences as co-determined, avoiding trait-style explanations of behavior. 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 re-conceptualizing (e.g., re-chunking and re-lating) 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 is sustained and developed by them.

This perspective makes salient functional aspects of behavior that were generally ignored by 1980s cognitive science studies of problem solving and instruction, in particular, the role of emotion in conceptual change. We develop a wholistic approach to understanding the experienced events, which facilitates relating biological and social aspects of learning: The conceptualized intangibles: Project, Activity (What I'm doing now), Attitude, Engagement/energy, Stage/Players/Experiences/Events, Persona – and "human factors": fatigue, hunger, postural discomfort, frustration.

The causal perspective of co-determination encourages us to recognize the uniqueness of situations, the inability to strictly control learning or activities, more broadly. We view an activity design (or the curriculum more generally) as a guide, not a fixed, optimal, or required path. We study each group diagnostically, emphatically, to understand its particular challenges, history, and opportunities.

It is difficult to imagine a claim that instructional design could be a science without specific hypotheses that certain aspects of an activity have predictable effects in certain situations. A transactional perspective doesn't rule out generalizations in the classroom any more than it ruled out generalizations in cell biology (section "Inter-action vs. Transaction"). One would expect at least rules of thumb for guiding discussions, and even activity toolkits that reliably produced energetic participation, questioning, and insights.

To conclude, I suggest that the following (at least) are required to develop a practice-based science of teaching and learning:

- Extensive observation and comparative analysis on different organizational scales (sessions, teachers, schools) – both repeating instructional activities like this graphing sequence and comparing with alternatives.
- Quantitative analyses of structure in classroom activities: Layouts, Phases, Rhythm, Participation, Regulation.
- Theoretical broadening of biological and social aspects, such as the musicality of ensemble performances in work groups, the nature and function of humor, the growth of identity, and the feedback relations of these dynamic processes: interpersonal regulation (articulation/co-construction) of norms, affective self-regulation, reflection and monitoring of progress, etc.
- Measurements that provide useful information for guiding learning.
- Extensive participation by stakeholders, including conversations within the home communities on what this research might practically accomplish.

In short, a transactional perspective might locate teaching in ever-broader contexts in which students will participate, helping them appreciate the theories, discourse, and tools of our society for structuring and interpreting experience.

Notes

1. This prescriptive notion of inquiry, often called "authentic learning" in the situated cognition debates (Brown, Collins & Duguid 1989), relates to an instructional design promoted as "cognitive apprenticeship" (Collins, Brown & Newman, 1986).
2. I am grateful to Jim Garrison for pointing out this passage. Garrison (2001) provides a highly useful introduction that complements and further explains the ideas I present in these sections.
3. On revising an early draft, I removed all colloquial uses of the word "interaction." In most cases, I now say "episode," which has the advantage of indirectly implying that I have bracketed the video stream and am viewing the resulting sequence as being a unit with certain properties. In other places I say "participation," e.g., in referring to the teacher's participation style (manner of being involved) during the students' presentation of graphs to the class. Later, on reading Burke (1994), I realized that I had been identifying "inquiry" with "solving problems," and went back to emphasize its more fundamental character.
4. Glenn's (2003) conversational analysis of laughter as a social interaction also distinguishes between reflex and intentional laughter, which he characterizes as two types of analysis, physiological and social. I am distinguishing instead between two kinds of experience with different temporal and attentional characteristics. Perhaps more importantly, I am viewing the episodes more broadly in terms of *play*, and not concerned with laughing *per se*.
5. This analysis is supported by theories that humor involves sustaining "mutually contradictory frames of interpretation" (Mulkay, 1988, pp. 32–35, cited in Glenn, 2003, p. 21). In contrast with the view that laughter involves a kind of physical relief of tension when attempting to relate incommensurate frames, a *humorous attitude* is an emotional means of keeping oneself oriented, while otherwise inconsistent conceptualizations are simultaneously active. This follows from Bartlett's (1932) analysis of the role of attitude in the action of remembering. Also, viewing the episode as a *communication*, Bateson's (1972) analysis of play suggests that "The message 'This is play' establishes a paradoxical frame" (p. 184), in which "These actions, in which we now engage, do not denote what would be denoted by those actions which those actions denote" (p. 180). Thus, Tyler's actions such as waving the paper in LS's face are not an attempt to disrupt the group and end the task, but perhaps to instill a different manner of working or relating.
6. An exception is Binsted and Ritchie (1997), which models humor as text manipulation using semantic networks, with some limited success in creating puns.
7. The six periods correspond to Excerpt 12 starting at [0:42:23], [0:43:33], [0:45:29], [0:48:31], [0:50:33], and [0:52:31]. Figure 13-5 was generated from an earlier transcript using a video without embedded time code, in which the start times were determined to be [0:42:28], [0:43:33], [0:45:30], [0:48:33], [0:50:34], and [0:52:31], ending at [0:55:39]. My original transcription also did not include interjections (e.g., [0:50:34–0:50:52]); I define a *turn* to be when one speaker has the floor and others are just exclaiming or briefly asking for clarification. With this qualification, the differences between Figure 13-5 and Excerpt 12 in Appendix B do not significantly affect the comparison of total and average turn durations for each speaker (Figure 13-6).
8. These categories are similar to those used in Conversation Analysis (e.g., Sacks, 1984), though my attention to details in the transcripts is much less formal.

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