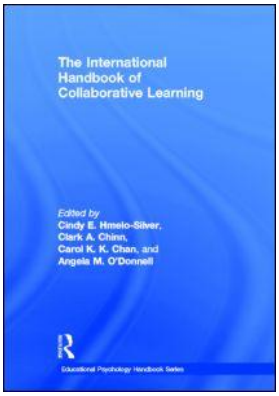

The International Handbook of Collaborative Learning

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QUALITATIVE METHODOLOGIES FOR STUDYING SMALL GROUPS

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INTRODUCTION

In a collaborative learning environment, students often talk to each other as they construct knowledge together. Collaborative learning environments often go by names such as project-based learning (Krajcik & Blumenfeld, 2006), problem-based learning (Hmelo-Silver & DeSimone, chapter 21 this volume), or inquiry-based learning (e.g., Slotta & Linn, 2009; Wells & Arauz, 2006). The teacher works closely with student groups to provide appropriate support and necessary information about relevant facts and procedures as they work to solve problems or to pursue project goals. The teacher often facilitates or channels the discussion, but if students are collaborating effectively an experienced teacher may realize that the best thing to do is to stay silent.

In contrast to the transmission and acquisition style of learning associated with lecture and explicit instruction, collaborative learning is more *improvisational*; the flow of the class is unpredictable and emerges from the actions of all participants, both teachers and students. Improvisational collaboration is difficult to achieve, and it requires substantial teacher expertise. The most effective uses of collaboration are what I have called *disciplined* improvisation (Sawyer, 2004, 2011); collaborative discourse among learners is more effective at achieving learning outcomes when it is improvised within broad structures and frameworks.

I use the term *collaborative emergence* to refer to improvisational and emergent group processes (Sawyer, 2003). Collaborative emergence is more likely to be found as a group becomes more aligned with the following four characteristics:

1. The activity has an unpredictable outcome, rather than a scripted, known endpoint.
2. There is moment-to-moment contingency: each person's action depends on the one just before.
3. The interactional effect of any given action can be changed by the subsequent actions of other participants.

4. The process is collaborative, with each participant contributing equally.

Collaborative emergence is a defining characteristic of social encounters that are improvisational, because only when the outcome is not scripted can there be unpredictability and contingency. Because collaborative emergence results from interactions among participants, it must be analyzed as a discursive, distributed process. My focus on collaborative emergence is closely related to studies of *distributed cognition* (Hutchins, 1995; Salomon, 1993) and *situated cognition* (Greeno & Sawyer, 2008; Lave & Wenger, 1991). Suchman and others (e.g., Winograd & Flores, 1986) argued for a perspective in which "the organization of situated action is an emergent property of moment-by-moment interactions between actors, and between actors and the environments of their action" (Suchman, 1987, p. 179). All of these perspectives argue that knowledge and intelligence reside not only in people's heads, but are distributed across situated social practices that involve multiple participants in complex social systems.

Collaborative emergence is characterized by improvisation, unpredictability, and responses that are contingent on each other. The meaning of a turn is not always clear at the moment it is spoken; meaning is often ascribed retroactively through a collective, discursive process (Cazden, 2001). During successful collaborations, the group constantly constructs and maintains *intersubjectivity* or shared meaning (Forman, 1992; Forman & McCormick, 1995, p. 151).

WHEN QUALITATIVE METHODS ARE DESIRABLE

Qualitative methods are particularly valuable in collaborations that are characterized by collaborative emergence. For example, in collaborations with a high degree of *contingency* (the second characteristic in the above list), one person's action at a given moment is highly influenced by the actions of their partners immediately before—such that prediction of a person's action cannot be made successfully, independent of the sequence of preceding actions of others. In such encounters, knowledge and action are often better viewed as social, rather than as located in the heads of individuals. When collaborative discourse is improvisational and emergent, its analysis requires a methodology that details the social interactions of the participants, in addition to the internal cognitive structures and mental models of those participants. In collaborative emergence, learning is an ongoing social process, and a full explanation of the processes of collaboration requires an empirical study of the moment-to-moment processes whereby individual actions result in the emergence of a collective outcome.

Qualitative methodologies are intended to reveal the improvisational mechanisms whereby groups learn through collaboration; they focus on the dynamics of collaborative dialogue, as it emerges over time. A focus on social interaction and on emergence over time is shared by many collaboration researchers; researchers from a wide range of theoretical perspectives have hypothesized that social interaction mediates between the group and individual learning (Fisher, 1993; Johnson & Johnson, 1992; Kumpulainen & Mutanen, 1999, 2000; Mercer, 1996; Vygotsky, 1978; Webb, 1991, 1995; Webb & Palincsar, 1996). Researchers that study collaborative learning have focused on three aspects of interaction that could contribute to learning. First, providing and receiving explanations are both thought to contribute to children's learning (Bargh & Schul, 1980; Fuchs et al., 1997; Swing & Peterson, 1982; Vedder, 1985; Webb, 1984,

1991, 1992; chapter 1 this volume). Second, researchers working within a Piagetian sociocognitive framework have emphasized the mediating role played by conflict and controversy (Bearison, Magzamen, & Filardo, 1986; Doise & Mugny, 1984; Miller, 1987; Perret-Clermont, 1980; Piaget, 1932/1948, 1950). Third, researchers working within a Vygotskian or sociocultural framework have emphasized how participants build on each other's ideas to jointly construct a new understanding that none of the participants had prior to the encounter (Forman, 1992; Forman & Cazden, 1985; Palincsar, 1998).

All of these aspects of collaboration are conversational phenomena; explanations are provided in the context of the ongoing collaborative discourse of the group, and argumentation and elaboration are fundamentally discursive notions. In the sociocultural tradition emerging from Vygotskian and related theory, studies of collaboration have focused more specifically on discursive interaction (Durán & Szymanski, 1995; Forman, 1992; Gee & Green, 1998; Hicks, 1995, 1996; Palincsar, 1998; Richmond & Striley, 1996; Wells & Chang-Wells, 1992). Much of this research has combined Piaget's emphasis on cognitive conflict with Vygotsky's emphasis on social interaction, to develop a view that knowledge is coconstructed in social settings (Kelly, Crawford, & Green, 2001; Musatti, 1993; Rogoff, 1990, 1998; Tudge & Rogoff, 1989; Verba, 1994), and that meanings are socially constructed through discursive interaction (Lemke, 1990; Wells & Chang-Wells, 1992). An emphasis on the processes of group interaction, rather than educational outcomes, has been a defining feature of the sociocultural tradition.

These three distinct traditions—cooperative learning, Piagetian sociocognitivism, and Vygotskian socioculturalism—have reached a consensus that the processes of social interaction are the mediating mechanism whereby collaboration contributes to learning. In the late 1990s, the idea that conversational interaction is responsible for the benefits of collaborative learning inspired a burst of research in how discourse contributes to learning. Studies have examined the discourse processes of collaboration in science (Boxtel, van der Linden, & Kanselaar, 2000; Finkel, 1996; Green & Kelly, 1997; Kelly & Crawford, 1997; Kelly, Crawford, & Green, 2001; Klaasen & Lijnse, 1996; Richmond & Striley, 1996); math (Chiu, 2000; Cobb, 1995; Cobb, Gravemeijer, Yackel, McClain, & Whitenack, 1997; Saxe, 2002; Saxe & Bermudez, 1996; Sfard & Kieran, 2001; Sfard & McClain, 2002); and literacy education (Durán & Szymanski, 1995; Gumperz & Field, 1995; Nystrand, Gamoran, Kachur, & Prendergast, 1997; Tuyay, Jennings, & Dixon, 1995). Many educational researchers have noted that collaborative discourse results in the emergence of new insights and representations, and that once they have emerged, these interactive social constructions both constrain and enable the ongoing collaboration (Cobb et al., 1997; Sawyer, 2003; Saxe, 2002). In this "emergent perspective" (Cobb et al., 1997; Saxe & Bermudez, 1996), a complete understanding of educational collaboration requires a focus on both individual development and on social change over time (Saxe & Bermudez, 1996). In group discussion, both the overall group dynamic and each individual's learning collaboratively emerge from the group's conversation.

INDIVIDUAL AND GROUP LEARNING

Within traditional individualist cognitive science, the study of learning focuses on how mental structures change within the mind of the learner. Traditionally, cognitive scientists focus on the activities of individuals as they answer questions, solve problems, study texts, or respond to stimuli. Cognitive explanations are models of the processes

that individuals use to construct, store, retrieve, and modify patterns of information. Concepts and methods for analyzing these knowledge structures are the main focus of traditional individualist cognitive science.

Qualitative methods are particularly useful when the researcher is interested in studying both group learning and individual learning, and how they interrelate. In the *situative view* (Greeno & Sawyer, 2008), learning at an individual level involves transformation of the individual's participation in an activity system and occurs as part of a transformation of that activity system. Focusing only on individual learning, as traditional cognitive scientists do, requires an assumption that the cognitive processes involved in collaboration can be decomposed in such a way that specific elements can be associated with specific individual participants. But situative researchers have shown that collaborative groups differ in whether they are organized in ways that support such decomposition. The interactions of extremely improvisational groups, such as jazz or improvisational theater groups (Sawyer, 2003), are not decomposable in this way with our current methods of analysis, and for these collaborations, isolating the learning of any one individual would require more powerful analytical concepts and methods.

Learning scientists are interested in the learning associated with individual participants, as well as the learning that corresponds to transformations of group processes. Studying both forms of learning simultaneously is difficult, and this is an example of a general difficulty facing scientists who study complex systems: whether to proceed by reduction to study of the components, or by holistic study of the entire system (Sawyer, 2005). Qualitative methods are particularly useful in analyzing three levels simultaneously: starting with the symbolic interaction among members of the group, working up towards an analysis of the emergent group properties that result, and working down toward an analysis of the thinking processes and knowledge structures perceived and constructed by one or more of the individuals participating in the group.

A BRIEF HISTORY OF QUALITATIVE METHODS

Perhaps the first scientific studies of interaction were conducted by Bales (1950). Researchers watched people interacting, and, using a specially prepared coding sheet, checked off behaviors of interest as they occurred. However, this method was limited because even a trained observer cannot keep track of the overlapping activities of several different people; and the interpretations of the observer can never be subjected to later disconfirmation in any rigorous way. (For similar reasons, interviewing participants after the fact to discern what they remember about an encounter does not provide sufficient data to understand an encounter.)

In the 1960s, researchers first gained access to audio recording equipment, which allowed them to listen repeatedly to the same sequence of interactions and to produce accurate and detailed transcripts of verbal utterances. This resulted in a methodology known as *conversation analysis* (Psathas, 1995; Koschmann, chapter 8 this volume). Conversation analysts focused extremely closely on the microsecond dynamics of conversation that most people remain unaware of, and they created new methods of transcription to capture what words on the page cannot—pauses in speech, sighs, interruptions, and overlapping speech—as in this transcript of the beginning of a phone conversation, prepared by Emanuel Schegloff:

Example 1. Initial dialogue of a phone conversation (from Schegloff, 1986, p. 114).[1]

1		(phone rings)
2	Nancy	H'llo:?
3	Hyla	Hi:,
4	Nancy	^Hi::.
5	Hyla	Hwaryuhh =
6	Nancy	= Fi:ne how'r you,
7	Hyla	Okay: [y
8	Nancy	[Goo:d,
9		(4 second pause)
10	Hyla	'mkhhh [hhh
11	Nancy	[What's doin,

We can all recognize this as an extremely ordinary conversation, but even though it's familiar, the transcript reveals many aspects that we all take for granted. For example, in line (3), Hyla does not introduce herself but simply says "Hi." The colon after the "i" indicates an elongated vowel—she draws out the "i" sound. Nancy's line (4) indicates that she recognizes Hyla's voice: she starts with a sharply higher pitch, indicated by the caret "^"; her volume is louder, indicated by the underlining, and she elongates her "i" vowel even longer than Hyla did. These subtle speech cues send several messages: In line (3) Hyla signals that she is a close friend and expects to be recognized simply by her voice; in line (4) Nancy signals that she has recognized her, and signals her pleasure at receiving the call.

In the remainder of the segment, the overlapping speech (indicated by the square brackets), the long pause at line (9), and the elongated vowels all symbolize a high degree of intimacy between these speakers. If we heard the tape of the conversation we would all "know" this at some subconscious level, but only with a detailed conversation analysis can we delve into the microsecond interactional features through which these understandings are possible.

Almost from the beginning of conversation analysis, researchers have applied these analytic methods to classrooms. The first study to tape and transcribe classroom discourse was reported in the 1966 book *The Language of the Classroom* (Bellack, Kliebard, Hyman, & Smith, 1966). They established a methodology that is still used today: they began by segmenting classroom discourse into interactional turns, or what they called "moves" by analogy with a board game. They then identified the speaker of each turn. And in the most important methodological step, they developed a system to categorize the interactional function of each move. After doing this, they looked for *teaching cycles*: routine sequences of moves that occurred frequently. They discovered that the most common teaching cycle, 48% of all cycles identified, was:

1. Soliciting move by teacher in the form of a question;
2. Responding move by the student addressed;
3. An optional evaluative reaction by teacher.

Interaction analysts usually refer to this kind of repeating sequence as an *interactional routine*. Interactional routines have a loose structure that is understood by participants who share a culture, and they all know how to participate in the routine to bring it off smoothly. For example, the first few turns of a phone conversation (Example 1) are a routine. Interaction analysts have also discovered that almost all routines allow for variation; although they specify the basic flow of interaction, there are often branching possibilities and flexible spaces for improvisational action. There are many different ways that the beginning of a phone conversation could play out, depending on the relationship between the speakers and the goal of the phone call; these all represent variations on the same basic routine.

The methodology used by Bellack et al. in 1966—segmenting conversation into turns, and then applying analytic codes to each turn—is subtly but importantly different from conversation analysis, because it does not involve detailed microsecond transcriptions, and overlapping speech is typically ignored. As a result of these differences, most scholars reserve the term *conversation analysis* for studies that use detailed transcription methods, and close qualitative analysis of single episodes of conversation (see Sawyer & Berson, 2004, summarized below). I use the term *interaction analysis* to refer broadly to all methodologies used to study verbal and nonverbal interaction, including the detailed methods of conversation analysis, the coding techniques of Bellack et al., and many others.

Interaction analysis was pursued at two U.S. institutions in the 1970s and 1980s: Michigan State University's Interaction Analysis Laboratory (1975–1988), which focused on medical settings, and Xerox Palo Alto Research Center and the Institute for Research on Learning, which studied a broader range of settings including mealtime conversation, mother–infant communication, children at play, human–machine interaction, and various forms of technology-mediated communication in the workplace (Jordan & Henderson, 1995). Interaction analytic methods were used in a series of important studies of classroom discourse in the 1970s. Sinclair and Coulthard (1975) studied the same routines as Bellack et al., but they extended the analysis by developing a more complex system of move types. Mehan (1979), who called this routine Initiation, Response, Evaluation (IRE), analyzed the ways that teachers and students improvise variations on the basic format of the routine, and the ways that these routines connect together to form an overall one-hour lesson.

By the 1980s, conversation researchers had a good understanding of traditional classroom discourse. They had ample documentation of exactly how the transmission-and-acquisition style of teaching was realized in the classroom. Just at this time, the learning sciences were demonstrating that transmission-and-acquisition styles of teaching like the IRE routine were not the most effective style for learning (Sawyer, 2006). As a result of findings emerging from the learning sciences, classrooms began to change their structure away from the transmission and acquisition model in which the teacher lectured or controlled the flow of discussion through IRE sequences. Studies of situativity and collaborative knowledge building convinced many teachers to have their students work together in groups, jointly engaged in a project, actively constructing their knowledge together (Greeno, 2006; Krajcik & Blumenfeld, 2006; Scardamalia & Bereiter, 2006). The collaborative learning conversations that occur in these classrooms are very different from traditional discourse patterns like IRE.

THE SIX STEPS OF INTERACTION ANALYSIS

Many education researchers believe that it is important to study collaborative interaction as it occurs in real-world settings: this is referred to as *naturally occurring conversation*. A group of students in a laboratory, working on an artificial task, may talk very differently than they would in a classroom. As a result of these concerns, the learning sciences have developed nonexperimental methodologies to study collaboration. These qualitative methodologies, which I refer to collectively as *interaction analysis* (following Jordan & Henderson, 1995), are designed to analyze naturally occurring conversation; in classrooms, naturally occurring conversation is the talk of students as they engage in their normal classroom activities. These methodologies have been central in the learning sciences since the early 1990s; several articles describing methodologies to analyze learning interactions have been widely influential among learning scientists, including (Chi, 1997; Jordan & Henderson, 1995; Lemke, 1998).

Standard interaction analysis procedures generally involve six steps (also see Jordan & Henderson, 1995).

1. *Videotape naturally occurring encounters as part of a broader ethnographic study, often using participant observation—when the researcher is an active participant in the interactions*. Interaction analyses often begin with an ethnographic phase, an essentially anthropological approach where the researcher is embedded in the learning environment for an extended period of time. The goal of this extended "participant observation" is to gain insights into the implicit cultural beliefs and practices of the community—those unstated assumptions that participants are often not consciously aware of, and thus not able to describe in interviews.

Conversation analysts, in contrast, rarely conduct full-fledged ethnographies, instead capturing single episodes on videotape. They argue that a broader ethnographic study is unnecessary, because any contextual or cultural factors that are relevant to the participants will become obvious by how participants behave during the interaction: the external context is only important to the extent that it is "demonstrably relevant to participants" (Schegloff, 1992a, p. 215; also see Schegloff, 1991). Thus, "if some 'external' context can be shown to be proximately (or intrainteractionally) relevant to the participants, then its external status is rendered beside the point; and if it cannot be so shown, then its external status is rendered equivocal" (1992a, p. 197).

2. *Once videotapes are made, the first analytic step is to watch through the videos and prepare a content log—each identifiably distinct episode is given a heading and a rough summary of events.* Content logs enable a quick overview of the dataset, allowing quick identification of episodes related to specific research questions, and guiding the decision about which portions of the data to transcribe in detail.

3. *Perhaps the most critical stage is the identification of general patterns—sequences of interaction that occur repeatedly and that provide insight into the nature of distributed creativity.* In practice, interaction analysts often index digital video data so that instances of similar events can be observed together. (Video analysis software like Transana supports such indexing.) The process proceeds inductively—attempting to develop statements about general patterns from multiple sets of empirical data.

4. *Depending on the researcher's interest, some portion of the video dataset is selected for transcription.* Transcription methods vary in detail depending on the researcher's interest; in some cases, only talk is transcribed; in other cases, nonverbal details such

as eye gaze and body position may also be important and recorded along with talk. In some cases, details of pauses, breathing, and overlapping speech are transcribed (following conversation analytic methodology); in other cases, only the words are transcribed.

5. *For many research questions, it can be valuable to quantify video data by coding the data.* Coding involves several steps (following Chi, 1997; Lampert & Ervin-Tripp, 1993): (a) delimit the stream of data into distinct episodes (these could be as large as "conversational encounters" or as small as "utterances," depending on the research question); (b) develop categories, or codes, within which the episodes can be grouped; (c) use two or more researchers to assign codes to each episode, and then calculate intercoder reliability of the coding scheme. The coding process is typically iterative, because often the initial coding scheme makes it impossible to attain reliability across coders and must be revised repeatedly. Once a reliable coding scheme is developed, and the many episodes found in the video data have been coded, then quantitative methods can be used to identify generalizable patterns.

6. *Some interaction analysts ask the original participants to watch the videotapes with the research team, with the goal of eliciting the participants' perspectives on what was happening* (Calderhead, 1981). This is sometimes referred to as "stimulated recall." Either the researcher or the participant can pause the videotape, to discuss how the previous dialogue emerged, and to explore the participant's own understanding of what is happening.

Interaction analysis is difficult and time consuming. A relatively small study might involve 6 months of participant observation, followed by another 6 months of transcription, coding, and interviews. But this sort of analysis has the potential to expand our understandings of the step-by-step processes whereby learning emerges from collaboration, and of the relationship between the distributed learning of the group, and the individual learning of each member of the group.

TWO KEY TENSIONS IN STUDIES OF COLLABORATION

In choosing a methodological approach, studies of collaborative learning always must balance two key tensions: how to blend inductive and deductive approaches, and to what degree to quantify naturally occurring data.

Inductive vs. Deductive Approaches

Bales's (1950) approach was a deductive approach: he derived his coding categories from Parsons's (1951) structural-functional theory, and then applied them to his observations. In contrast, most later qualitative methods took a more inductive approach, allowing their analytic categories to emerge from their observations. A particularly influential approach in qualitative methodology is grounded theory (Glaser, 1992; Glaser & Strauss, 1967). Grounded theory involves both inductive and deductive approaches in a process known as *constant comparison*: tentative coding categories are developed initially by reading field notes or transcripts, and then an iterative cycle continues, of comparing categories and merging and renaming them. The end result is a relatively stable set of coding categories that can then be applied to the data.

All studies of collaboration begin by making a choice about how to balance induction and deduction. The more quantitative methods associated with experimental designs tend to rely more on deduction; they begin with a theoretically motivated hypothesis,

a set of variables and categories derived from the theory, and then they gather data to evaluate that hypothesis. More qualitative methods tend to incorporate a higher degree of induction, providing a greater range of possibilities to emerge from the data. As a result, more inductive methods are more likely to result in the development, construction, and modification of theory.

Quantification

In Step 5 above, I noted that many qualitative researchers choose to code their data, resulting in an abstracted representation of the data that is then amenable to quantitative analysis—such as descriptive statistics that show the percentage of occurrence of one action or another, and how those might differ in different collaborative contexts or with different speakers.

Some collaboration researchers are opposed to such quantification. For example, Schegloff (1993), drawing on an ethnomethodological paradigm, argued that coding and quantification were unnecessary in the study of collaborative discourse. Ethnomethodology represents an "explicit preoccupation with the procedures by which commonsense knowledge is acquired, confirmed, revised, and so on" (Schegloff, 1992b, p. 1298). Schegloff argued that analysts should focus on the interpretations that participants apply to discursive acts; and that coding schemes do not accurately reflect the understandings of participants. He further argued that discursive acts always only carry meaning in a particular sequential context of ongoing talk, and cannot be coded independently from their sequential position. As an example, he referred to instances of *back channeling*—when listeners say things like *uh huh*, *yeah*, or *mm hmm*. These are generally not intended to interrupt the speaker—but sometimes they do serve that function; Schegloff and other ethnomethodologists argued that the meaning of any conversational action is always determined by the interpretive response it receives from the other participants.

All collaboration researchers have to make a decision about how to balance the more in-depth understanding that results from a qualitative analysis, versus sacrificing some depth of understanding in exchange for the more generalizable and quantifiable data that results from coding.

THREE EXAMPLES

In the rest of this chapter, I provide summaries of three different approaches to interaction analysis. These three examples demonstrate how the six basic steps outlined above can be applied differently depending on the context of the collaboration and the research goals.

These three examples demonstrate how each researcher chooses a different level of detail for its analysis. The first two examples are taken from projects in which the researchers analyzed many hours of classroom discourse. When researchers gather a large amount of interactional data, they cannot analyze each episode in as much detail, simply due to time constraints—because interaction analysis is labor-intensive and time-consuming. The third example takes the smallest level of detail, using a conversation analytic methodology—with detailed microsecond transcription of interruptions, pauses, and overlapping speech. This example is taken from a study that analyzed only 12 minutes of conversation. I chose these examples to demonstrate the important

methodological choice facing all interaction analysts: choosing an appropriate level of detail, one that corresponds to the research questions of the study.

Example 1: Computer Scaffolding for Scientific Collaboration

The learning sciences have found that the best way for students to learn science is to have them engage with science content in the same ways that professional scientists do. Kelly and Crawford (1996) argued that for students to participate authentically in a scientific community, they need to learn to use the language of science. They designed a computer-based lab for 12th grade science students with the intention of engaging the students in conversations about physical phenomena and giving them a chance to learn how to talk scientifically.

They studied groups of three and four 12th graders, and transcribed their conversation as they analyzed oscilloscope graphs that recorded the students' motion as they walked near a motion detector. The motion detector was attached to the floor, and when students walked by it or hopped up and down next to it, the oscilloscope would display a sine wave that represented the vibration of the floor. Kelly and Crawford analyzed each 45-minute group session by (a) breaking down the episodes into turns of dialogue; (b) identifying the ways that small episodes were put together to form larger participant structures; (c) using these larger units to identify patterns of interaction. Example 2 shows a sample transcript, and Figure 7.1 shows how the researchers represented these multiple levels of structure. They then identified *action units*, which were composed of one or more message units and defined as having a semantic relationship with each other, and which represent a single intended action by a group member. Action units represent the thinking that students chose to display publicly. In Figure 1, action units appear as vertically elongated rectangles in the "Map" column. Third, they identified *interaction units* composed of one or more action units. Interaction units include an action and a response. In Figure 7.1, interaction units are separated by arrows between action unit blocks in the "Map" column. The longest interaction unit starts with Nancy's question in line 236, and ends with Steve's response in line 244.

Example 2. Transcript analyzed in Figure 7.1.

Laura	That is really neat	looking at computer screen
Nancy	Do big circles Jump up and down	to Laura
Computer	the representation appears	
Nancy	So why does it go lower? Distance versus time so when you get closer, it goes further this way?	Nancy moves the mouse others look at the screen
Steve	[No, that's probably] just how far	Steve points to screen
Nancy	[No, that's time]	Nancy points with mouse.
Laura	That's time	
Steve	How far it is away	
Nancy	Time is that, and, and, distance is this when you're that close you go crazy Go crazy far away	Points with mouse Looks at Laura Shakes the mouse

line #	Nancy	Steve	Laura	computer	map	non-verbals	codes
232			that is really neat		r+	to computer screen	responding
233	do big circles				r+	to Laura	
234	jump up and down				r+	intiates an experimental run	
235				*produces representation*	r+	laughter (Nancy, Steve, Laura)	responding
236	so why does it go lower?				q+	Nancy moves mouse, others	looking for clarification
237	distance versus time				r+	look to the computer screen	demonstrating
238	so when you get closer				r+	"	claiming
239	it goes				r+	"	"
240	further this way?				q+	"	"
241	~no that's time~	~no that's probably~just how far			r+ r+	Nancy pointing with mouse. Steve points to screen	demonstrating (Nancy), claiming (Steve)
242			that's time		r+		
243		how far			r+		
244		it is away			r+		
245	time is that				r+	Nancy pointing with mouse while	claiming (Nancy)
246	and				r+	nodding her head	
247	and				r+	"	
248	distance is				r+	"	
249	this				r+		
250	when you're that close				r+	Nancy looks to Laura	
251	you go crazy				r+		
252	go crazy far away				r+	Nancy shakes the mouse	

Figure 7.1 A transcript of three students working together at a computer. From left to right, the columns represent the line numbers, the three speakers, the computer's actions, the discourse analysis map, the nonverbal actions, and the researcher-assigned codes. Source: Figure 3 (p. 699): Kelly, G. J., & Crawford, T. (1996). Students' interaction with computer representations: Analysis of discourse in laboratory groups. *Journal of Research in Science Teaching, 33*(7), 693–707. Copyright 1996 by the National Association for Research in Science Teaching.

Kelly and Crawford focused on how the students' conversations made use of the computer display's representation of motion. At the level of the turn, the transcript reveals what information students choose to make public. At the level of the action unit, the transcript reveals how turns are tied together to accomplish purposeful activity. The researchers used this level to understand the many different ways that the computer was used by students. In Figure 7.1, both verbal and nonverbal activity show how the computer is drawn into the conversation. Kelly and Crawford identified five ways that computer representations enter student conversations. In these five types of interaction, the computer is treated as a member of the group, participating almost as another entity in the conversation:

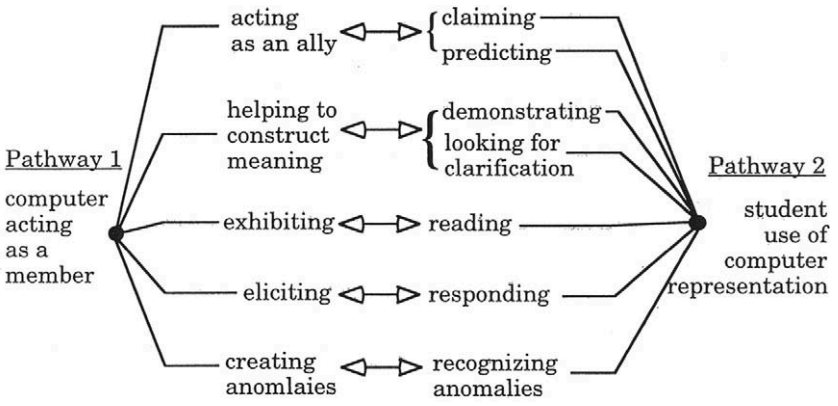

Figure 7.2 A list of the ways that computer representations are used in a conversation among three students. In Pathway 1, the computer functions as a fourth member in the conversation; in Pathway 2, the computer is used by a student in conversation. Each function in Pathway 1 is linked to its related function in Pathway 2. Source: Figure 5 (p. 703): Kelly, G. J., & Crawford, T. (1996). Students' interaction with computer representations: Analysis of discourse in laboratory groups. *Journal of Research in Science Teaching, 33*(7), 693–707. Copyright 1996 by the National Association for Research in Science Teaching.

- The computer is used by a student to support his or her efforts to make a case.
- The computer helps the group to construct meaning, for example by clarifying conceptual differences in the group.
- The computer is an external representation of important data.
- The computer elicits student responses (an example is line 235 in Figure 7.1).
- The computer presents students with unexpected information that sometimes is difficult for them to explain within their existing conceptual framework.

On other occasions, the computer representations are used by each student participant; instead of treating the computer as another participant, they are treating it as a source of support for their own position (see Figure 7.2). As a result, the computer has a special dual status in the group that makes it uniquely effective at supporting learning.

Example 2: Potential Pitfalls of Collaboration

Sfard and Kieran (2001) studied collaborative conversations in math classes, to evaluate the common claim that many school subjects are best learned through collaboration. They collected 2 months of videotape data from a pair of 13-year-old boys learning algebra (Sfard & Kieran, 2001). After the 2 months of collaborative work, both boys' math scores had increased above the class average, seeming to demonstrate the value of collaboration. But the researchers believed that the collaboration had not been as effective as it could have been; for example, although both boys' scores increased, one of the boys increased much more than the other. They conducted an interaction analysis to better understand what happened.

They analyzed two brief episodes extracted from their total of 30 hours of videotape. One of these was a discussion of how to understand a graph of the number of hours of daylight by the day of the year near the North Pole (showing 24 hours in the summer and 0 hours in the winter). They were asked to "Describe what happened to the number of hours of daylight over the year" and then given a series of five scaffolding questions such as "During which period of time did the number of hours of daylight increase most rapidly?" The transcript of one episode of this discussion appears in Figure 7.3.

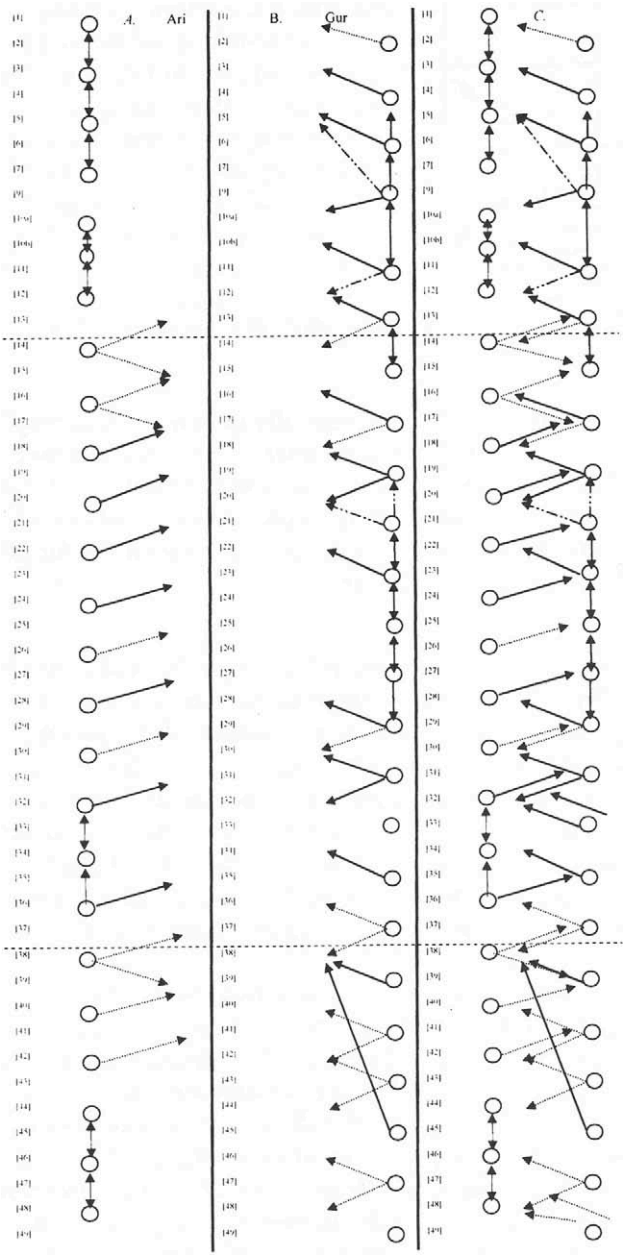

Figure 7.3 A transcript of two students analyzing a graph of the number of hours of daylight, throughout the year, at a point near the North Pole. Source: Figure 2 (p. 45): Sfard, A., & Kieran, C. (2001). Cognition as communication: Rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. *Mind, Culture, and Activity, 8*(1), 42–76. Copyright 2001, Regents of the University of California on behalf of the Laboratory of Comparative Human Cognition.

Sfard and Kieran developed a new method of coding the transcript, one that resulted in an *interaction flowchart* (Figure 7.4). Ari is shown in the left column, Gur in the center column, and their combined actions in the right column. Each circle represents a single utterance that corresponds to the transcript in Figure 7.3. A *reactive* arrow points

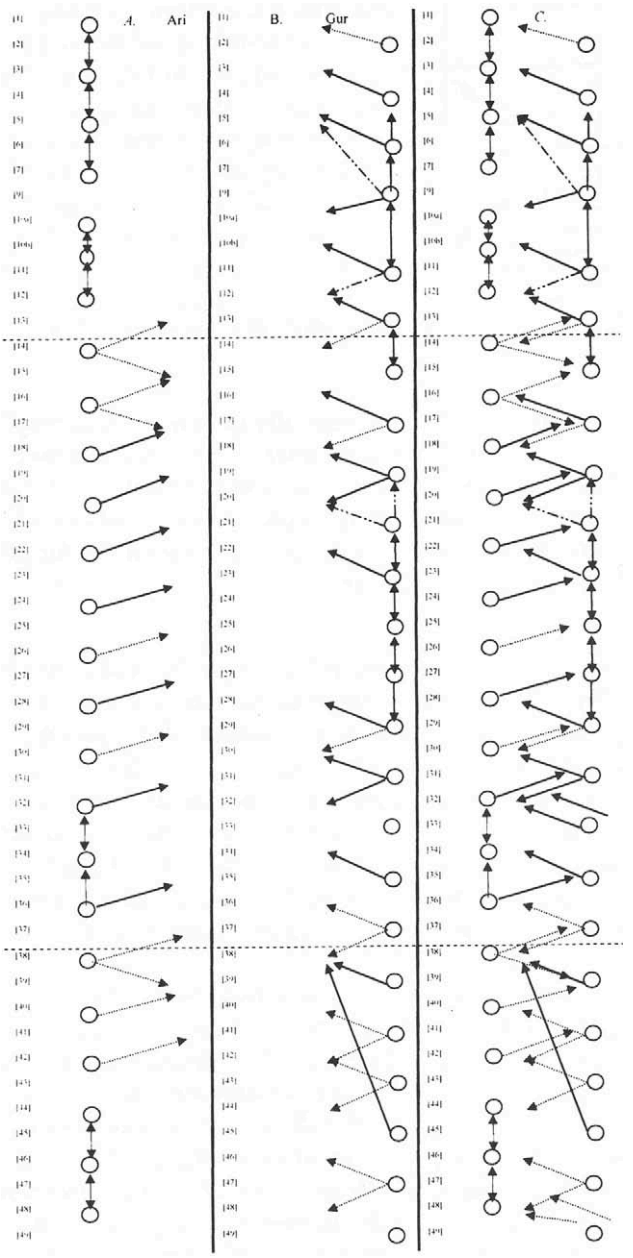

Figure 7.4 An interaction flowchart of the transcript in Figure 7.3. Ari's actions appear in the left column, Gur's in the center column, and a combination of both is shown in the right column. Up diagonal arrows are responses to previous utterances; down diagonal arrows invite responses from the other student. Source: Figure 6 (p. 59): Sfard, A., & Kieran, C. (2001). Cognition as communication: Rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. *Mind, Culture, and Activity, 8*(1), 42–76. Copyright 2001, Regents of the University of California on behalf of the Laboratory of Comparative Human Cognition.

vertically or diagonally backward or upward, expressing the fact that the utterance is a reaction to the pointed-to utterance; a *proactive* arrow points vertically or diagonally forward or downward, symbolizing the fact that the utterance invites a response, and that the following utterance is expected to be a reaction. Note that a proactive arrow is drawn even if the next utterance turns out not to actually be a response; this would happen in cases of miscommunication or ignoring. Vertical arrows relate utterances by the same speaker, and diagonal utterances relate the two speakers.

This visual coding method reveals several important facts that show why this discourse was not as effective as it could have been. First is that Ari's first column has almost no proactive arrows—meaning that Ari was not directing his comments to Gur—he made very few response-inviting utterances. And although he made some reactive utterances, these were not very responsive—they were more often than not simple statements of disagreement. In contrast, Gur made many proactive statements; he attempted to sustain contact and encourage response. The visual coding method shows that Gur was interested in true communication whereas Ari was not. Interpersonal interaction seemed to interfere with Ari's thinking. Sfard and Kieran concluded that Ari was focused on solving the math problem, even if alone, while Gur was focused on the interaction itself. And while both boys' scores increased above the class average, Ari's final score was much higher than Gur's. They concluded that collaborative problem solving involves a trade-off between the needs of managing interpersonal communication, and the need to engage in individual thinking (p. 64). As a result, many students may need explicit coaching in how to participate in effective collaboration (Azmitia, 1996).

Example 3: Emergent Moments of Insight

In an analysis of the collaborative discourse of a university study group, Sawyer and Berson (2004) examined how students in a psychology class used their lecture notes to help structure their collaboration and their joint learning. During their study group discussion, the students mostly each looked down at their own notebooks while they were talking; but occasionally, they looked up at each other and engaged in conversation without looking at the notebooks. Conversation research has repeatedly demonstrated the importance of eye gaze in managing turn-taking and speaking rights (Goodwin, 1981; Kendon, 1990; Viechnicki, 1997).

Sawyer and Berson discovered that the conversation unfolded in very different ways, depending on whether or not the students were looking up at each other, or down at their notebooks. We identified three differences in conversational dynamics. First, when students were looking at their notebooks there was less *back channeling*. "Back channeling" refers to verbal and nonverbal communications made by the listener while the speaker continues talking. Second, when students were looking at their notebooks there was less overlapping speech, whereas overlapping speech frequently occurred while they were looking up. Third, while looking at the notebooks the participants left longer pauses between turns and within turns. For example, in the first turn of the transcript, Mary reads from her notes, and during this utterance, no back channeling occurs. Contrast Beth's turn, of comparable length and content, in (4). Susan and Mary each nod twice during this turn and Mary back channels with the word *yeah* once:

(1) M: *And, so Healy comes up with the U-Unitization Hypotheses that says that eventually, complex patterns are processed as whole units. The stimulus doesn't require any ((4))*

(2) S: *So that's just a hypothesis, it's not necessarily…?*

(3) M: I- I guess it's just like a (2) conclusion almost, um ((4))
Sa: *(nods)*

(4) B: Probably because related to the thing above- umm- we probably see the words like "of" like, a lot, so then it's auto[matic,] so that's probably why. (3)
Sa, M: (nod) M: [Yeah.] (nod)
Sa: (nod)

The use of the notebooks provided students with two different ways to engage in collaborative discourse. They could talk while each attending to an external representation, or they could talk directly to each other. The latter style had more of the characteristics of everyday conversation: verbal and nonverbal back channeling, overlapping speech, and shorter pauses.

Learning through Collaborative Discourse

Discursive phenomena like overlaps and back channeling are fundamentally interactional and collaborative, and would be difficult to identify if one did not transcribe the discourse in detail, or if one coded only individual turns of speakers, in isolation from the unfolding stream of discourse. Those three contrasts were revealed by applying the detailed transcription notation of conversation analysis, and this has demonstrated the potential value of conversation analytic methods for studies of educational collaboration. However, it is not yet clear how these contrasts affect individual and group learning.

Occasionally a speaker shifted eye gaze within a turn; there were eight instances of shifts from looking up to down, and 15 instances of shifts from looking down to up. These shifts served several distinct pedagogical functions. Perhaps the most interesting was that a shift from looking down to up allowed the speaker to revoice lecture material in her or his own words. When students read from their lecture notes, they are generally speaking in a scientific style of discourse, invoking the authoritative voice of the professor. The change in eye gaze corresponds to a change in voice—from the instructor's voice as encoded in the lecture material, to the student's own voice commenting on that material. Turn (11) demonstrates this revoicing pattern. Beth summarizes the LaBerge and Samuels model, and at the point where she looks up, she begins to revoice what she has already said. She originally uses the technical term *recognize*, and after looking up, changes her wording to the more colloquial "you're gonna pay more attention." Beth's mode shift occurs at the same time that she revoices her lecture notes.

(11) B: *So like the younger you are, the (1) more you're gonna recognize,* you're gonna pay more attention to each, each step.

These shifts in eye gaze serve an important educational function: they provide students with a technique to help them construct their own understanding. Within the sociocultural perspective, learning is a creative appropriation of material (Rogoff, 1998).

Many researchers have focused on the differences between authoritative scientific discourse and everyday discourse, examining how teachers help students to appropriate scientific or mathematical forms of speech (Forman, 1992, 1996; O'Connor & Michaels, 1993). The use of the notebooks as mediating artifacts scaffolds students in the use of two discursive styles—a scientific style and an everyday style—and these are used as collective tools by students to help them appropriate the material. By revoicing the lecture material in their own words, the students appropriate it and thus enhance their own comprehension of the material. These analyses of students' shifts in eye gaze show how collaborative discourse with external representations helps participants to advance from simply memorizing lecture material to making it their own.

Group Learning through Collaborative Discourse

A focus on discourse allows the researcher to examine patterns of collaboration that emerge from the successive actions of speakers. Sawyer and Berson (2004) found that discussion of a topic began primarily with all students examining their notebooks; the group began their discussion of each topic by reading from their notebooks. Throughout the discussion, discourse gradually began to incorporate more and more face-to-face conversation, as the group members looked up and conversed about the topic, revoicing the lecture material, and making connections to personal experience or to other lecture material. Finally, the topic unit concluded with all students looking up before moving to the next topic unit. This overall pattern is evidence of a collective group learning process. The pattern is not planned in advance, but emerges from the improvisational flow of the group's collaboration (cf. Cobb, 2002). The group's collective shift to a conversational style supports a learning process in which the group members gradually absorb the material and become less reliant on the notes. The external representations function as a scaffold for a collective appropriation of the material; as the group discussion proceeds, the scaffold is needed less and less—the typical pattern of guided participation emphasized by learning scientists.

Note that this emergent group pattern is parallel to the within-turn pattern identified above: individual speakers shift from looking down to looking up to revoice notebook material. The shift in eye gaze serves a similar function both at the individual level and at the group level; the external representations of the notebooks scaffold both individual learning and collective learning. This is one of the benefits of external representation that have been documented by studies of CSCL (Stahl, 2006). The detailed transcription methods of conversation analysis resulted in the identification of an emergent group-level process of guided participation—where the external representation is gradually used less and less, as students increasingly revoice and appropriate the information.

LIMITATIONS

Qualitative methods can be used to study several aspects of collaborative learning: argumentation, communication, and critique; externalizing and articulating knowledge; how group patterns and communities of learners scaffold individuals in authentic practices. This kind of study requires an extended analysis over a longer period of time, and results in a large amount of data. For example, one paper that combined interaction analysis and cognitive content required 80 published pages (Cobb et al., 1997), and that length is not unusual.

The transcripts in Sawyer and Berson (2004) contain a large amount of detailed, microsecond notation. Generating this type of transcript is incredibly time consuming; if research goes into this much detail, it is only practical to study a rather small amount of discourse. Researchers who use the detailed transcription notation developed by the conversation analysts typically focus on only a few isolated cases at a time. The advantages of this method are that it can reveal implicit understandings and cognitive competencies that could not be discovered any other way. Transcribing a lot of detail, including overlapping speech, interruptions, and backchanneling, can provide many insights into the distributed, collaborative nature of group activities that are otherwise missed. Transcribing eye gaze, for example, can reveal a lot about how joint focus and intersubjectivity is established and maintained in groups. This is particularly important when two or more students are working together at a computer (or more generally, in the presence of shared external representations); without detailed transcriptions of where the students are looking, it will be difficult to fully explain the role of external representations in mediating collaborative learning.

The disadvantage of this method is that it can only focus on one small segment of the complex flow of a classroom. A 30-second segment of conversation can easily take 10 hours to transcribe. Consequently, the studies by Sfard and Kieran and by Kelly and Crawford did not use this level of detail. Their transcriptions were more in the style of a screenplay: just the words spoken, leaving out volume and pitch marks, elongated vowels, and overlapping speech. The disadvantage of transcribing this way is that a lot of information is lost; and often, the importance and relevance of that detailed information doesn't become apparent until the transcript analysis stage. But the advantage is that it becomes feasible to study a much larger volume of discourse. An entire 1-hour class can often be transcribed in 10 hours.

Researchers who take a more narrow approach typically use the more qualitative methods of conversation analysis. With this approach, it can take an entire journal article to identify everything educationally relevant that is going on in a 30-second segment of discourse. The advantage is that this level of detail can often provide highly nuanced insights into what each participant must have known at each moment, and can identify the exact moment when a group of learners is constructing a new understanding. It is difficult to analyze emerging understandings in authentic, situated contexts any other way; stopping the interaction to administer a test of each student, for example, would destroy the situated nature of the activity.

Researchers who take a more broad approach typically categorize each of the turns of conversation using a *coding manual* that specifies what type of conversational turn qualifies as an example of each category. Because a large number of hours can be studied simultaneously, it becomes possible to apply quantitative and statistical methods to the database of turn codes. For example, classrooms at two different schools can be studied, and their broad conversational patterns can be contrasted statistically. And like the very first study of classroom discourse in 1966, descriptive statistics can indicate how often a given sequence of turns occurs, and what contexts are most likely to result in a particular sequence. Another advantage with the broad approach is that it becomes possible to group turns into higher-level organizing units, as Kelly and Crawford did.

CONCLUSION

Qualitative research methodologies can contribute to our knowledge of collaborative learning in several ways. First, they provide the researcher with a method to study how peer groups learn both with and without a teacher present. In many learning environments based in learning sciences research, teachers act as facilitators, providing guidance that fosters collaborative emergence in student dialogue (Sawyer, 2011). And several decades of research into cooperative groups has proven that peer groups contribute to learning. However, this tradition has not examined the conversational dynamics of these groups; studies of cooperative learning primarily focus on individual outcomes, task structures, and incentive structures (e.g. Slavin, 1990). The studies I have reviewed here demonstrate how qualitative methods can allow us to look inside the "black box" of collaboration (Bossert, 1988–1989) to identify specific discourse processes that make collaboration a uniquely effective learning environment.

Second, qualitative methods can reveal the interactional mechanics whereby external representations affect discourse processes and learning. Learning scientists have explored the important educational role played by articulation and externalization. Qualitative methods can extend this work by examining how the discourse processes of the group are mediated by these representations. As in the three examples given here, external representations act as scaffolds that guide the group's activity, and this guided participation seems to allow a group to attain a higher level of shared focus and intersubjectivity.

The learning sciences have increasingly examined the conversational dynamics of educational classroom talk. Many of these studies have focused on short, isolated episodes of discourse. Qualitative methods can also be used to examine the longer-term emergent patterning of educational talk (Cobb & McClain, 2006). For example, Sawyer and Berson (2004) found that students always engaged in a period of talk on a given topic by looking down at their notebooks, and only later did they begin to engage in face-to-face conversation on that same topic. This pattern collaboratively emerged from the group's conversation, and it became an important element contributing to the educational value of collaboration.

Qualitative methods have the potential to reveal how these emergent patterns can contribute to individual learning. Very few studies have examined how collective group phenomena emerge from extended sequences of discourse, and how these unintended emergent effects might then contribute to learning; rather, most studies of classroom discourse have examined the knowledge that students are meant to learn, often by focusing on individual students in the classroom. For example, Sawyer and Berson (2004) found that a speaker sometimes begins talking while reading from the notebook, invoking the instructor's voice, and then looks up to revoice the material in his or her own words. This shift served as an interactional technique that scaffolded students in their appropriation of the lecture material. The fact that this sequential pattern is reproduced on both the individual and the group level suggests that external representations guide not only individual learning but also group learning. These analyses suggest that a full explanation of collaborative learning requires a simultaneous examination of both individual and group processes.

NOTE

1. Transcript conventions can be found in (Atkinson & Heritage, 1999) and are summarized as follows:
   [] overlapping speech
   ((*x*)) unintelligible speech of *x* seconds
   (*x*) a pause of *x* seconds
   = indicates two turns were spoken together without any pause, or "latched"
   : elongated vowel each colon indicates one second of elongation
   __ (underlining) emphasis
   ˆ Pitch rise
   , a comma indicates a pause of less than one second
   - an en dash at the end of an utterance indicates flat pitch

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