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ADVANCING UNDERSTANDING OF COLLABORATIVE LEARNING WITH DATA DERIVED FROM VIDEO RECORDS

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The study of collaborative learning is a multimethod and multidisciplinary affair (Strijbos & Fischer, 2007). As the chapters in this volume attest, controlled experiments, ethnographic portraits, surveys, and qualitative or quantitative analysis of talk and interaction all have their roles to play in advancing our understanding of this vital form of human interaction. Hybrid or mixed methods approaches are increasingly used to integrate studies of interactional processes and learning outcomes in collaborative learning and education more generally (Creswell & Plano Clark, 2007; Maxwell & Loomis, 2003; Tashakkori & Teddlie, 2003). Our field seeks to better understand how technological tools and artifacts amplify or hinder productive collaborative interactions. What may be involved in planning and completing a study using video records? In this chapter, we consider the importance of theory inquiry cycles, the development of viewing practices, the usefulness of intermediate representations of video records, and we summarize how researchers use video records to create datasets and make claims about collaborative learning phenomena.

How exactly one approaches or should approach an analysis of collaborative learning using video recordings depends crucially on one's theoretical commitments, on the specific research questions being pursued, and on practical constraints of time, money, and personnel. A video analysis is high quality to the extent that the researcher can make a convincing case that one's analytic choices and argumentation connecting claims to data were sufficiently responsive to these considerations. Issues of reliability and validity of all kinds (internal, convergent, external, and descriptive) apply to video-based data as they do to any other kind of quantitative or qualitative data analysis. Concerns about generalizability of findings can be countered by explicit attention to the logic of one's inquiry, one's approach to collecting records, and an articulation of the processes used

to create explanations and generate claims. As a result, performing analyses with video recordings is frequently an iterative process that involves cycling between the video records themselves, one's evolving hypotheses and data interpretations, and a variety of intermediate representations for discovering, evaluating, and representing them for oneself and others.

Our chapter is organized into four sections:

Rationale: In this section we summarize aspects of collaborative interaction that make video records useful for investigations of this form of learning, and outline some of the research questions animating recent work with video.

Research: Here we organize our discussion around several types of research designs productively using video records as a core data source.

Strategies for representing and analyzing video records: In this section we share documented approaches to representing video data.

Approaches to reporting video-based analyses and making arguments: Here we present examples from the literature showcasing alternative ways that researchers share data and warrant claims connecting data to theory.

WHY USE VIDEO RECORDS TO UNDERSTAND COLLABORATIVE LEARNING?

Collaborative accomplishments are increasingly understood as involving the intertwining of cultural, cognitive, relational, and embodied phenomena. Hutchins (1995) argues that human intelligent action is productively conceived as an accomplishment arising from *properties of interactions* between people or between people and artifacts in the world. How a particular interaction unfolds depends on the efforts of the individuals involved, their understanding of the activity, the material and symbolic resources they have available, implicit or explicit conventions for proceeding with joint work, and the nature of the interpersonal relationships among partners.

A core implication of this view is that to understand the nature of productive collaboration, we need to articulate how social goals and discourse practices interact with knowledge building processes that lead to coconstruction of understanding. Clark (1996) uses the term *ensembles* to capture the interdependencies of partners in conversation. By focusing on the group or "ensemble," researchers can describe interactions that capture the dynamic interplay in meaning-making over time in discourse between participants, what they understand, the material and symbolic resources they use, the types of contributions that they make, and how they are taken up or not in a given discourse. Video records of interactions make possible the incorporation of multiple kinds of data into the analyses beyond talk. Silence, repetition of ideas, eye gaze, gestures, physical synchrony, laughter, pauses, interruptions, intonation, and overlaps in turn taking do not have single meanings but have a productive ambiguity so that depending on the context they can serve to signal different things to participants at different times (Kendon, 1982, 1997). Such behavioral displays become available through video interaction analysis for making sense of how interaction unfolds over time and for drawing out the relational and social aspects of collaborative problem solving (Barron, 2003). In addition, video allows researchers to replay the recording of collaborative interaction in order to gradually enrich their perceptions and understanding of

its moment-by-moment processes reflected through intonation, facial expressions, and body language in addition to conversation.

Attending to between-person processes has surfaced emergent properties of collaborative interactions. For example, the key notion of a "joint problem solving space" was generated from a video-based case study (Roschelle, 1992; Teasley & Roschelle, 1993). Phenomena such as coordinated mutual engagement (Bakeman & Adamson, 1984), as revealed through reciprocity, coregulation, and the degree of intent to collaborate are dimensions of collaborative activity that can be operationalized, measured, and analyzed from high quality video records. The intention to collaborate, or what has been called an "intersubjective attitude" (Crook, 1996), is expressed behaviorally and can be assessed by studying how a participant orients to others and by how willing they are to engage in coregulation of the interaction (Fogel, 1993), their attention to partner's contributions through acknowledgment or elaboration, and sharing of ownership over the work.

RESEARCH DESIGNS THAT USE VIDEO TO STUDY COLLABORATIVE LEARNING

Given the time-consuming nature of analyzing and collecting video records, one must plan carefully to make best use of one's resources. Although situations arise in which video already collected becomes the object of analysis (e.g., Goodwin, 1994; Leonard & Derry, 2006), ideally research video is guided by a research design and a set of research questions based on familiarity with the phenomena being studied. Such planning is particularly helpful when the researcher is new to video analysis. The amount of information captured in video recordings makes them a powerful resource when compared to what a human observer can record in real time, but provides corresponding challenges. Erickson (2006) argues that video records are not data but are resources for developing data. Turning records into data is enormously time consuming. Accordingly, it is sensible to develop a project with theoretically motivated questions that originate from the research literature and observations. Good orienting questions help maintain a perspective that prevents one from getting lost in the prolific bounties of information that video records open up to scrutiny.

Reflecting on which theoretically motivated questions to pursue can and should fundamentally influence strategies for data collection. For example, many investigators have found it fruitful to combine video records with other forms of data, such as interviews, performance data or surveys. Field notes, photographs of the surrounding field of action, copies of documents used, or artifacts created by groups can enrich the data derived from video records and offer opportunities for triangulation across multiple sources of evidence. We now describe several types of research designs that use video records, sometimes in combination with other data sources, and we provide examples of published studies, summarizing the questions that drove their design.

Ethnographic Studies

Several researchers have carried out video-based studies for examining how collaborative phenomena change over time in classrooms or workplaces. For example, Hall, Wieckert, and Wright, (2010) used analyses of videotaped interactions to understand how a group of entomologists collaborated with statisticians to find better ways to classify termites.

The more general questions driving the work included how people collaboratively make concepts general and shared and how work environments function as learning environments. Video was used to record typical periods of work and it was combined with biographical interviews, interviews focused on work activity, collection of working and published documents, and participant observations. These multiple forms of data collection reflected phenomena occurring at different time scales. Coordinating these data sources longitudinally allowed these researchers to articulate a number of processes that take place over substantial periods of time including describing how future work is assembled through narrative in conversation, how parables were used to position coworkers in alternative ways of working, and how infrastructure was established through analogical reasoning that built upon the prior work of other scientists.

Another example that fits into this category is a study of game play among children at home (Stevens, Satwicz, & McCarthy, 2008). This work also builds on a tradition of everyday cognition and had as a goal to describe how "in-game" activity is also tangled up with activity that is occurring "in-room." To capture both strands of co-occurring activity the team captures the game play directly from the computer or game console and a separate camera captures the "in-room" activity where the players are sitting, lounging, crouching, or reclining. Resources such as game manuals and interactions with family and friends are captured. The two video streams are then synchronized into a single image so that the analysts can view them simultaneously.

Experimental Designs Coupled with Video Capture

Several studies have combined experimental designs that vary some aspect of the collaborative situation with video capture of the interactions. These kinds of enhanced experimental designs can be productive for both theory building and for testing hypotheses (Maxwell, 2004; Shadish, Cook, & Campbell, 2002); in this case, about how an experimental manipulation might be influencing collaborative interactions. For example, Zahn, Pea, Hesse, and Rosen (2010) assigned dyads to one of two conditions that involved collaboratively designing a video-based web presentation for a virtual museum. The researchers combined and synchronized video recordings of the interaction between the dyads with digital screen recordings of the dyads' collaborative development of the multimedia website. In their experiment they compared the design processes and learning outcomes of 24 collaborating dyads that used two contrasting types of video tools for history learning. The advanced video tool WebDiver supported segmenting, editing, and annotating capabilities. In the contrasting condition, students used a simple video playback tool with a word processor to perform the design task. Results indicated that the advanced video editing tool was more effective in relation to (a) the students' understanding of the topic and cognitive skills acquisition; (b) the quality of the students' design products; and (c) the efficiency of dyad interactions. For the two experimental groups, in addition to quantitative comparisons of content knowledge, cognitive skills acquisition, measurable properties of the joint design products, and the distribution of talk content categories during their dyadic interactions, the researchers developed case analyses of some of the dyads' collaborative processes to examine possible tool effects on microprocesses such as achieving common ground in dyadic interaction.

In an experiment that randomly assigned students to an individual or a group problem solving condition, video records made of the triadic sessions were used to explain differences in outcomes for different collaborative groups (Barron, 2000, 2003). The

video-based analysis was motivated by the observation of significant variability in quantitative group problem solving scores within the collaborative condition, despite random assignment of students to triads and equal levels of prior mathematical knowledge. The tapes were first viewed to assess whether or not correct answers were generated in discourse by all teams. It became apparent that in all groups the correct solutions were generated but in about a third of the cases they were never fully documented. Accounting for the differences between the teams led to a number of insights about the role of joint attention, and the proposal that collaboration might be productively thought about in terms of a dual problem space. In particular, Barron (2000, 2003) found that all groups faced coordination problems that could have prevented correct ideas from being recognized and used by the group. However, it was only the more successful groups that used verbal and nonverbal strategies for addressing these problems. They could be seen to maintain joint attention and ownership through mutual gaze and by "huddling" around workbooks. When documenting solutions, the writer might "broadcast" his or her writing and thus make it available for monitoring. In addition, some groups evolved more explicit expressions of metacommunicative awareness as indicated by their monitoring of joint attention and possible disruptions to it. Thus, as the detailed video analyses showed, successful coordination was accomplished through a variety of strategies that included the use of external representations, conversational devices, and physical moves; also see Mercier (2010) for another example.

Arranged Collaborations in Natural Settings

Another research design that productively allows for the study of collaboration involves arranging for intact groups, such as families or friendship pairs, to visit learning environments and then following their conversations with video. An example of this kind of design can be found in a study of the conversations of bilingual families during visits to an aquarium (Ash, 2007). The researchers recruited families who participated in a Head Start program and invited them to visit a particular set of exhibits on multiple occasions. The goal of the research was to describe the kinds of informal learning conversations that families produced, and how the content and form of their conversations changed over time. The research challenge in this kind of study is to figure out how to capture ideas that "emerge, submerge, and reappear in morphed forms, traceable over time but often only in hindsight" (Ash, 2007, p. 211), and how to capture family members' conversations or interactions with exhibits when they split off from the main group, as often happens. The solution for this team involved having separate microphones for each family member with one videographer following the groups, but also having audio recorders on hand for the times that members split up. They also used some of the video in interviews to gather data on what family members had been thinking about when they were looking at exhibits but not speaking (see Cherry, Fournier, & Stevens, 2003; Stevens & Toro-Martell, 2003 for another example of a video-based stimulated recall approach).

Hybrid Designs

Some video-based collaborative learning studies move between two or more of these approaches. For example, in a classroom study by Engle, Conant, and Greeno (2007), the research team began with a pre/post design. They used video to follow group and whole class discussions during an inquiry-based curriculum unit taking place in a fifth grade classroom, and included pre- and postassessments to measure changes in individual and

group conceptual understanding. This strategy allowed the team to make an explicit connection between the disciplinary discourse practices that were being used in whole class discussions and the small-group interactions that took place when students worked independently. However, like in ethnographic studies, the authors also reported findings that emerged during analysis and that were totally unanticipated. For example, at the prompting of a colleague they decided to look more closely at an instance of a conversation taking off. Though they had not anticipated this as a focus before they began the study, the video records allowed them to pursue it fully in the context of one group, which allowed them to propose general principles for fostering this and similar cases of productive disciplinary engagement (Engle & Conant, 2002). A second unanticipated focus was the important role that the teacher played in students' learning and transfer when she repeatedly attributed authorship of ideas and information to students (Engle & Conant, 2002; see also Engle, 2006; Greeno, 2006). Although the good questions the researchers started with were addressed, the novel phenomena were especially fruitful theoretically. Thus, formulating questions at a general level does not preclude more discovery oriented work with video records; in fact, this is one of their valuable properties—they can be revisited at different times with different viewpoints and by different researchers for continued learning and analysis.

STRATEGIES FOR REPRESENTING AND ANALYZING RECORDS: DATA CREATION, ORGANIZATION AND ANALYSIS

Video records are often rich with interactional phenomena, including eye gaze, body posture, content of talk, tone of voice, facial expressions, physical artifacts, as well as between-person processes such as the alignment and maintenance of joint attention (Barron, 2003). It is easy to become lost in detail and so explicit strategies for focusing the attention of the analysts are needed. Strategies are also needed for establishing the content of the tapes and making decisions about how to represent the phenomena included within them. Erickson (2006) provides three sets of guidelines, each reflecting different approaches to inquiry along the inductive-deductive orientation. He provides suggestions about stages of viewing, types of summaries to make at each stage, the importance of time code, and ways to enhance perception by slowing down or speeding up the tape or watching without sound. These suggestions are very helpful for the beginning or experienced researcher. Yet as we will summarize below, there are numerous ways to go about understanding video records of interaction and building up an analysis.

Practices for Analytically Viewing Video Data

One advantage of video recordings as a source of data is that they can be viewed multiple times in different ways, with different people, at different times in the history of a research project, and even across research groups. Investigators can strengthen their research findings by coordinating what they learn from multiple viewing opportunities. In early stages of a video analysis, before interpretations of events become fixed, it can be quite helpful to share a key video segment with a group of other researchers in order to gather multiple interpretations of the events and to brainstorm potential issues to investigate more deeply (Jordan & Henderson, 1995). The video segment can be viewed and

reviewed to look for data consistent or inconsistent with initial hunches about what's going on for those involved in the interaction. Watching the video at speeds slower or faster than normal or simply listening to the audio or watching the video can also be used to focus analysts' attention on particular aspects of interest (Erickson, 1982). Group viewing can be used in later stages of work to see whether multiple researchers notice similar phenomena (e.g., Engle et al., 2007). Finally, it can sometimes be helpful to have participants from the events that have been recorded watch the video in the presence of the researcher in order to provide their own interpretations of what was going on. It is preferable to obtain participant reflections as soon as possible after recording and without imposing leading questions (Ericsson & Simon, 1980, 1993; Jordan & Henderson, 1995). It is also important to recognize that such participant interpretations do not provide researchers with access to "what really happened" or what the participant was "really thinking," but instead represent whatever interpretation of the interaction the participant now has that he or she considers acceptable to present to the researcher. Thus these accounts needed to be treated as one data source among many that can be used to understand the collaborative interaction.

Intermediate Representations for Data Selection and Pattern Finding

Various kinds of what we refer to as "intermediate representations" of the video records are important for identifying which segments of collaborative interactions to analyze and for beginning to see patterns within and across segments. Transcripts of talk and nonverbal information are common and we will mention a variety of approaches to this method of representing the content of video records. Often researchers construct other kinds of intermediate representations to better understand their video datasets and start the process of pattern finding. Such representations can help the researcher decide what should be transcribed and at what level of detail as well as the focus of later analyses. Below we describe several approaches to intermediate representations and the variety of decisions that are involved in using them.

Indexing. Indexes to events in a given videotape are one kind of intermediate representation. The first opportunity to interpret the phenomena of interaction recorded by the video is while it is being collected. If a researcher can be present during recording, then he or she can make time-indexed field notes that provide a basic outline of the events or possible examples of phenomena of interest that occur (Hall, 2000). This also provides an opportunity for filling in relevant complementary information that may be difficult to discern later from the video. Absent this stage, it is still very helpful if a researcher can quickly watch the video soon after its capture to create a content log, which like the field notes provides a time-indexed outline of the video events. Content log notes can be extremely detailed, taking a brief standard unit of time (e.g., 1 minute) and describing the major events that took place, or they can consist of a several sentence description of the content of a whole hour of instruction. Field notes and content logs allow the research team to develop a sense of what is in the corpus of data and facilitate the selection of episodes for subsequent detailed analysis (Jordan & Henderson, 1995). This kind of indexing should be distinguished from systematic coding, which, as we will discuss, is best done after extensive work has been completed to establish the meaning of codes and the central units that should be coded.

Transcription. Although there are exceptions (e.g., see Angelillo, Rogoff, & Chavajay, 2007), during the process of video analysis most researchers produce transcripts that re-represent the events recorded in their video. Initial transcripts may help researchers flesh out from their field notes or content logs what occurred in a particular segment of video in order to decide whether and how to pursue an analysis (Jordan & Henderson, 1995). In later stages of research, transcripts are iteratively revised while analyses of the video recordings proceed until they gradually provide a reliable record of what the researchers view as the most relevant aspects of the video for providing evidence relevant to their research questions (e.g., Engle et al., 2007; Mischler, 1991). *Accuracy* is a relative term for transcripts, and minute aspects of speech timing, intonation, body posture, etc., are relevant to some but not other research questions. Like a map, a transcript's features are integrally tied to the purposes it is designed to serve, and it is thus theory-laden. Whether explicitly intended or not, transcripts end up embodying theoretical commitments about the events that were recorded (Lapadat & Lindsay, 1999; Ochs, 1979). Through this process, transcripts become key data that can be used directly for additional coding, interpretation, or creation of other analytical representations. However, when research is written up, transcripts must be edited for public consumption in order to illustrate a study's analyses or findings (e.g., Du Bois et al., 1993).

There are many existing—and in many cases competing—conventions for how one might transcribe different aspects of the social interactions captured on video (Atkinson & Heritage, 1984; Dressler & Kreuz, 2000; Du Bois et al., 1993; Edwards & Lampert, 1993; Lapadat & Lindsay, 1999; Ochs, 1979). Typically, researchers adapt existing conventions in ways that make sense given their research questions, their theoretical commitments, and practical constraints like available time and personnel, the audiences for their work, and the systematic availability and accessibility of information in the video record and other data sources. The important thing is to explain how one's own choices of conventions for use make sense given these various considerations. We provide a synopsis in Table 11.1 of common choices made in producing transcriptions.

Macrolevel Coding. Because transcription is costly and time consuming and not always suited for pattern finding, video researchers often invent ways to summarize video records more synoptically. For example, Ash (2007), who studied family conversations in museums, begins with a representation she calls the "Flow Chart" which catalogs a family's museum visit from start to finish, including any pre/post interviews that were conducted. The goal is to mark major events and the occurrence of conversations about biological themes. Topics and themes can be coded from this representation in order to compare families across visits or visits across families. The flow chart representation is also instrumental for selecting the data used in her second level of analysis—the *significant event*. Significant events are selected based on four criteria: (a) they have recognizable beginnings and endings (usually they take place in one exhibit); (b) they have sustained conversational segments; (c) they integrate different sources of knowledge; and (d) they involve inquiry strategies such as questioning, inferring, and predicting. The third level of analysis involves more microlevel examinations of the interactions occurring within selected significant events. For example, Ash and her team use discourse analytic frameworks to study how an idea develops over time.

Table 11.1 Common Transcription Choices (expanded from Edwards, 1993, p. 19)

Aspect of Transcript	Common Options	Considerations
Spatial arrangement (Edwards, 1993; Jordan & Henderson, 1995; Ochs, 1979)	• Playscript • Organize into columns • Musical score (e.g., Erickson, 2003)	• Common playscript format is most accessible to a wide audience, but awkward for showing overlaps and multimodality • Columns good for distinguishing relative contributions of different speakers and/or types of actions • Musical score helpful for showing precise timing of actions with respect to each other as well as even rhythm and pitch
Notation of words (Du Bois et al., 1993)	• Orthography (dictionary spellings) • Using the International Phonetic Alphabet (IPA, 1996) • Noting other word features – variants: "gonna" – unfinished words: "mis-" – disfluencies: "uh," "um" – vowel lengthening: "we:::ll" – emphasis: ALL caps, bold, or underlining – voice quality: "[excitedly]"	• Standard orthography is easiest to read • Phonetic alphabet useful when exact pronunciation is important for research questions; if so, also consider waveform software • Similarly, record those other word features that are relevant for your research questions
Signaling uncertainty (Atkinson & Heritage, 1994)	• Unclear words in ( )'s: "(yeah)" • Unheard words: [inaudible] or (xxx-xxx), with # of xxx's indicating number of inaudible syllables	• Very important to note when something is missing or unclear • Indicate number of missing syllables when word length crucial • Descriptions of actions can signal uncertainty directly with hedges: "appears to," "maybe," etc.
Units for segment-ing discourse (Chafe, 1980; Dressler & Kreuz, 2000; Gee, 1999; Gumperz & Berenz, 1993)	• Intonation or idea units: – "," to mark fall-rise intonation – "?" to mark rising intonation – "." to mark falling intonation • Spoken turns-at-talk • Stanzas or narrative sentences • Events or episodes	• Does the grain size of your units correspond with those of your coding schemes and other analytical methods? • Some recommend dividing speech into units one level lower than the lowest level of coding and/or analysis you will do • Each unit reflects a different theory about discourse structure: are the units you are using consistent with your own view?
Pauses (Atkinson & Heritage, 1994; Du Bois et al., 1993)	• Record only especially salient ones by annotating them: "[pause]" • Record pauses as shorter or longer relative to the speaker's speech rate: "(.)", "(..)", and "(…)" for increasingly longer pauses • Time all pauses over a particular length: "[1.2 sec pause]" or "(1.2s)"	• How important are speakers' pauses for understanding the phenomenon you are studying? • For purposes of your study, is it more informative to relativize pauses or objectively time them? • What theory of discourse does this decision reflect?

(*continued*)

Table 11.1 Continued

Aspect of Transcript	Common Options	Considerations
Overlapping speech and other actions (Dressler & Kreuz, 2000; Du Bois et al., 1993)	• Record beginnings of overlaps using paired /'s or large ['s • Record beginnings and endings of overlaps using paired sets of [ ]'s • Record timings of overlap by spatially aligning them on a musical score transcript or on adjacent lines in a playscript transcript	• Is it important for your study to know about when overlaps end as well as when they begin? • What level of precision (nearest word, syllable, or phoneme) do you need? If the latter, then consider looking at waveforms. • Musical transcript best for precisely depicting timing of overlaps
Visible actions (Bavelas, 1994; Goodwin & Goodwin, 1996; Leander 2002a; McNeill, 1992)	• Insert screenshots • Create line drawings • Physically describe actions: "[*shakes head up and down*]," "[*touches board with index finger at equation*]" • Characterize likely meaning: "[*nods yes*]," "[*indicates equation*]"	• Which is the quickest method that provides the information you need given your research questions? • Degree of interpretation increases from screenshots to physical descriptions and drawings to meaning characterizations • To what degree do you need raw data vs. interpreted data? If differing interpretations of a visible action would significantly affect the findings, then may need both.
Other things to consider recording in transcripts (Edwards & Lampert, 1993)	• Specific people addressed by an utterance, especially if not all who are present: "[*to Nathan*]" • Gaze or body direction: "[*looking at Marcia*]" "[*facing board*]" • Laughter (see Du Bois et al., 1993) • Anything else potentially relevant to research questions	• As with everything, include only what matters for addressing your research questions, but there is no need to do it all at once. Instead you can systematically refine transcripts as needed. • Descriptions can be set off in brackets in the examples to the left • But they can also be put into separate columns devoted to particular kinds of information as in a columnar transcript

Narrative Summaries. Other researchers employ narrative accounts to analytically capture events on a tape. For example, Angellio et al. (2007) conducted a video study that compared mother–child interactions in four distinct cultural communities. Their first step was to generate descriptive, narrative accounts of each 90 minute-long video recorded home visit during which mothers helped their toddlers learn about the novel objects. These were not event logs but comprised descriptions of events as long as 30 pages. These descriptive accounts were used to help the rest of the research team visualize the sequence of interactions and to capture the purposes and functions of action and dialogue. Engle, Langer-Osuna, and McKinney de Royston (2008) extended this approach by creating explanatory narratives that were focused specifically on explaining a particular phenomenon by coordinating within the narrative the particular theoretical concepts that were being investigated.

Diagrams. Other researchers summarize aspects of video records using still frames or diagrams that show spatial or other coordinations. For example, in a study that investigated patterns of joint activity between Guatemalan Mayan mothers and children completing puzzles the goal was to categorize patterns of joint attention, mutual orientation, and ways of distributing work (Angelillo et al., 2007). A representational innovation that turned out to be important for the team was the creation of a diagramming method that allowed the researchers to characterize types of coordination around shared tasks that involved multiple people. The diagrams were then used to help code 1-minute intervals of video. Similarly, Leander (2002b) and Engle, McKinney de Royston, Langer-Osuna, Bergan, and Mazzei (2007) used synoptic bird's-eye diagrams to characterize students' relative spatial configurations and the social relationships they embodied; Barron (2003) complemented narratives with still images in an analysis of variability in small- group interaction. For additional inspirational uses of diagrams captured from still frames and annotated for analytical purposes, see Chuck Goodwin's papers (e.g., Goodwin, 2003, 2007).

APPROACHES TO REPORTING AND MAKING A CASE

In this section we discuss several major approaches to analysis and refer the reader to additional examples in the literature.

Play by Play

One common way of reporting a video analysis in a publication is providing a "play-by-play" description in which interpretations of episodes that follow each other in time are presented sequentially. Play-by-play analyses are particularly effective at showing how the sequential context that has been created so far in an interaction informs what happens next. With rich transcripts to support them, these kinds of analyses also are particularly good at demonstrating how multiple actions and people collectively produce collaborative and other social phenomena. Finally, in an extension of play-by-play analyses, a researcher might analyze selected episodes that all focus on a particular topic or other issue over the course of days, weeks, or even months to show how that issue was transformed over time. In one well-known longitudinal study, Ninio and Bruner (1978) followed one mother–infant dyad engaged in joint picture-book reading, using video recordings of their free play in a period between 0;8 and 1;6. They found this activity very early on had the ritualized structure of a dialogue in which learning is by participation rather than imitation. The child's early communicative forms of babbling, smiling, reaching, and pointing were richly interpreted by the mother as expressing the child's intention of requesting or providing a label, and later the child uses lexical labels in these same dialogical slots. Other examples of this approach in the published literature include Engle (2006), Koschmann, Glenn, and Conlee (1999), Ochs and Taylor (1996), and Wortham (2004).

Coding, Counting, and Statistical Analysis

Methods of analysis that code videos are rooted in practices of *disciplined observation*, a core feature of scientific methodology. Independent of the advent of video technologies, social scientists developed approaches that allowed them to document, analyze, and report human behavior to their colleagues. For example, scientists interested in

child development created formal approaches for observing, recording, and describing the natural world in ways that were convincing to others who followed positivist empirical traditions. Systematic observational approaches relied on preestablished coding schemes and were designed to yield reliable judgments by independent observers of behavior taking place in natural contexts. Techniques for narrowing the foci of observation through methods such as time sampling, event sampling, or focal person approaches were articulated and used in many early studies of child development, and later, human and animal behavior more generally (see Altmann, 1974 for a highly influential paper on sampling methods for observational study of behavior).

For example, early studies of children's play often relied on what was called repeated short samples (Goodenough, 1928) where a child would be observed for one minute a day and their play coded into one of six mutually exclusive categories (Parten, 1932). After a substantial number of observations were made, proportions could be computed so as to draw conclusions about how a particular child or category of children spends their playtime. Statistical approaches for determining interrater reliability were key innovations that allowed researchers to determine whether their coding approaches led to similar observations across human coders. Before video, these methods required that the focus of inquiry and coding systems were well worked out before the collection of data and were simple enough for two or more observers to achieve interrater reliability after only a single viewing. Video relieves this constraint such that coding systems can be developed over time after the analysts decide what to code.

Despite the number of studies that use coding approaches for video (and the many tools used to support them: Derry et al., 2010; Pea & Hoffert, 2007), it is by no means universally agreed upon that data derived from video records should be primarily coded in a way that can yield quantitative data to yield theoretical and empirical insights. Many researchers prefer to focus on examples (such as in the play-by-play approach) and do not care for counting types of events within or across cases. However, others find coding and quantification a useful aspect of their project. Erickson (1977, 1982, 1986) has written extensively about possible roles of quantification in qualitative research and has a useful discussion of the synergies between approaches. He argues that determining what to count is more challenging than doing the actual counting. Schegloff (1993) adds to this discussion with a set of criteria he believes are necessary to satisfy for the quantification of interactional data to be meaningful. Other excellent discussions of the development and use of observational coding schemes and associated statistical techniques include a primer on the topic of sequential analysis by Bakeman and Gottman (1997) and a paper by Chi (1997).

In video-based research, coding and other systems of analysis often develop over the course of multiple research projects. For example, Ash et al. (2007) articulate the changes that have occurred in her coding system and the evolution that resulted in a system they call Tools for Observing Biological Talk Over Time (TOBTOT). Through the careful analysis of the talk of families, consultation with biologists, psychologists, and educators, and through the work of her research team, they have developed a system that can be used across projects and by teams outside their research group. She notes that more than a dozen iterations have occurred to get to what they consider to be a stable yet generative analytical system. Another example is provided by Meier, Spada, and Rummel (2007) who developed coding systems for capturing the quality of collaboration using video and extended the system to study online collaborating learners.

Like the processes of generating questions or creating representations, the development of a coding approach benefits from iterative cycles and distributed expertise. For example, Angelillo et al. (2007) describe one approach to investigating patterns of shared engagement that combines qualitative and quantitative methods. The core of the process involves close ethnographic analysis of a few cases in order to build up a coding scheme based on the observed phenomena that can then be applied to multiple cases. They illustrate this approach in their study focused on cultural variation in mother's and toddler's contributions to understanding novel objects across four culturally distinct communities. The research team approached their analyses having in mind the kinds of interactions that might differ across the four cultural groups. For example, they expected some differences in the relative reliance on words vs. nonverbal demonstration. However, as is the case with many video studies the video-based data of interactions led to the discovery of new phenomena such as differences in ways the mothers from different cultures motivated engagement. Once these phenomena were identified the team worked to refine the definitions of the categories so that they could be reliably coded.

Analytic Induction and Progressive Refinement of Hypotheses

In a recent volume on video research in the learning sciences, many research groups contributed chapters including rationales and detailed accounts concerning their video practices (Goldman, Pea, Barron, & Derry, 2007). This volume provides examples of studies that interweave both top-down planned analyses while also reporting unanticipated phenomena. Some authors describe processes that share a family resemblance with an approach to qualitative research, more generally called analytic induction, developed by Znaniecki (1934). In analytic induction a few cases are explored in depth and explanations are developed. New cases are examined for their consistency with the explanations and when they are not consistent the explanation is revised.

A similar approach offered by Engle et al. (2007) is "progressive refinement of hypotheses." In this approach a general question is framed, and video and related records are collected in an appropriate setting. Once records are collected, more specific hypotheses are formed after preliminary viewing of the records. These hypotheses are then examined in relation to other aspects of the dataset leading to more encompassing explanatory hypotheses until both data and theoretical ideas have been exhausted. They argue that multiple iterations through hypothesis generation and evaluation leads to greater robustness and increased likelihood that the findings will be replicated in other contexts. A similar approach was proposed earlier by Cobb and Whitenack (1996).

Reporting Results

Although there have been some attempts to create multimedia journals that could include video as part of the publication (e.g., Beardsley, Cogan-Drew, & Olivero, 2007; Sfard & McClain, 2002) and fully multimedia video-based papers (e.g., DiMattia, 2002), in most cases the video records will be left behind in the reporting phase of the project and what was observed must be re-represented in written form. Coding and subsequent quantification is a common approach to reporting results. However, while our ability to code behaviors can rest on the well worked out techniques and methods described earlier there is still the limitation of losing the context of an interaction. Narrative description is another method of representation; although there are well-warranted accounts of the distinctive values brought by narrative accounts to understanding human interaction,

they may also be considered less credible to many experimentally minded social scientists (for National Science Foundation workshop reports on the scientific foundations of qualitative research, see Lamont & White, 2009; Ragin, Nagel, & White, 2004). Others revise and then share their intermediate representations, though such representations can easily be opaque to readers who are not provided with careful preparation for what to look for within the records.

One solution to the reporting problem is to use multiple methods of representation in reporting video research. For example, Barron (2000, 2003) used quantitative methods to find response patterns that reliably differentiated more and less successful collaborative groups. However, the ways these sequences unfolded for individual groups differed in some important ways that were masked by the quantification. Thus she combined what Bruner (1986) described as a paradigmatic approach (coding and statistical analysis) with a narrative approach (that preserved the sequence of interactions). Her narrative approach employed three types of representations to convey the complexity of interaction: transcripts to illustrate key aspects of dialogue; behavioral descriptions that conveyed aspects of the interaction such as facial expression, tone, and gesture; and still frames to further illustrate the body positioning of the interacting students at key points.

The problems of re-representing the complexity in video are not trivial and we are in the beginning stages of figuring out as a field creative ways to do this. We can learn a great deal from one another's attempts to do this well within and across disciplines. Erickson (2006) provides a particularly strong argument that readers of analyses should not only come away "tree-wise" but "forest-wise" (p. 185). That is, it is not enough to provide rich examples, the analysts must also provide a sense of the broader sample and how typical or atypical the instances presented are relative to some larger corpus of data. In addition as Lemke (2007) has emphasized, it is also important that we draw on video to represent processes that develop over different timescales and how they interact with each other. Our discussion therefore has suggested ways of communicating multiple levels of analysis and their interrelationships

CONCLUDING COMMENTS

There is an increasing desire to better understand the transactional processes involved in the coordinated unfolding of collaborative interaction over time and for this effort video records are needed. In this chapter we have described the kinds of video-based research designs that have been used to enhance collaborative learning research, shared some especially helpful strategies for the analysis of video records and the subsequent reporting of findings. For those starting to plan a project that will use video records it is wise to focus first on theory-driven questions and develop concrete plans for a first pass at using the video records. Having good questions will help maintain perspective and prevent one from getting buried in the cornucopia of human interactional phenomena at play. At the same time, one should anticipate new discoveries and be ready to articulate questions that can be followed, refined, and tested through multiple passes in analyzing the video records. These passes can be made most fruitful by using intermediate representations. Multiple cycles are to be expected and an explicit approach to this objective can strengthen the likelihood of generating strong findings that are both reliable and valid.

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