GUIDELINES FOR VIDEO RESEARCH IN EDUCATION

RECOMMENDATIONS FROM AN EXPERT PANEL

Sharon J. Derry (Editor)
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The Data Research and Development Center (DRDC) is a research and technical center funded by the National Science Foundation (NSF) as part of the Interagency Education Research Initiative (IERI), a collaborative effort of NSF, the U.S. Department of Education, and the National Institute of Child Health and Human Development (NICHD) in the National Institutes of Health. Since 1999 these three agencies have funded over 100 IERI scientific research studies designed to develop and/or investigate the effectiveness of educational interventions in classrooms across the United States. DRDC conducts research to understand the factors that are essential for scaling up promising educational models, programs, and strategies. DRDC also works to identify and address the methodological and other challenges that arise when conducting scale-up research, and to support IERI investigators in the conduct of their research.

To learn more about the work of the Data Research and Development Center and the IERI projects it supports, please visit our website at http://drdc.uchicago.edu, or contact: Sarah-Kathryn McDonald *(773 256 6199)* or Kevin Brown *(773 256 6024)*.

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This report can be accessed online at http://drdc.uchicago.edu/what/video-research-guidelines.pdf. A users' guide for the report also is available and can be found at http://drdc.uchicago.edu/what/video-research.html.

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1. Introduction to the Guidelines

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> *Every technology has a philosophy which is given expression in how the technology makes people use their minds, in what it makes us do with our bodies, in how it codifies the world, in which of our senses it amplifies, in which of our emotional and intellectual tendencies it disregards. (Neil Postman as cited in Gore, 2007)*

With Neil Postman's argument in mind, we assert that the development and widespread availability of affordable, usable, high-quality video technology is revolutionizing the practices of educational researchers. New types of video technology, including Internet applications, provide the educational research community with powerful ways of collecting, sharing, studying, and presenting detailed cases of practice and interaction for both research and instructional purposes. Because many educational research projects now include a substantial video research component, and because use of video in educational research is growing rapidly and constitutes a broad range of practices, the federal Interagency Educational Research Initiative[1] (IERI) sought the assistance of qualified scholars to help develop standards for using video research in education. Accordingly, in December 2005, the Data Research and Development Center (DRDC), which provides administrative and technical support for IERI, convened a conference of leading researchers to address this issue. The conference program included presentations, discussions, and structured working sessions on topics such as video research in informal, peer, and naturalistic settings; video research on classroom and teacher learning; and advanced technologies for video collection, analysis, and archiving.

Conference sessions were recorded and summarized by the DRDC, and the resulting summary was developed into an outline for a white paper, which was vetted at the 2006 Annual Meeting of the American Educational Research Association by a committee of scholars representing the larger conference community. The committee concluded that it would be appropriate and beneficial to author a more detailed set of guidelines for the practice of video research in education, representing a consensus viewpoint of qualified scholars. The committee chose the word *guidelines* rather than *standards* to describe its recommendations, because the term standards might communicate an inappropriate degree of consensus and rigidity and thereby possibly hinder future productive explorations that currently are unforeseen.

[1] IERI is a collaborative effort jointly sponsored by the National Science Foundation (NSF), the Institute of Education Sciences in the U.S. Department of Education, and the National Institute of Child Health and Human Development in the National Institutes of Health (Brown, McDonald, & Schneider 2006).

The committee's guidelines address the following, sometimes overlapping, categories of video-based educational research:

1. Video collection that produces data for basic research on teaching and learning processes in formal learning settings such as classrooms, the goal of which is to help researchers understand and design formal learning environments;
2. Video collection that produces data for basic research on peer and adult-child interactions in informal settings, such as museums and homes, the goal of which is to help researchers understand informal learning that occurs in various contexts and design informal settings for learning;
3. Research on how people learn with and from video, the goal of which is to help researchers design educational environments that use video as a major tool for learning; and
4. Production and use of video cases for professional development, such as medical and teacher education, the goal of which is to provide objects to share and discuss within professional learning communities.

The guidelines do not advocate or represent a particular research method or set of methods. Video is an important tool that enhances the various methodologies – including ethnography, experimentation, discourse analysis, interaction analysis, and others – which can be combined and employed across all categories of work listed above. Regardless of method or category of work, video offers a means of close documentation and observation and presents unprecedented analytical, collaborative, and archival possibilities.

Thus we span all categories of video work and touch on various research methods in our six-chapter report addressing the following:

1. Video recording strategies;
2. Methods of data selection;
3. Analytical frameworks and practices;
4. Technologies and practices for reporting and sharing video research;
5. How people learn from video; and
6. Ethical considerations in collecting, analyzing, and using video data.

We hope this report will guide researchers and funding agencies, facilitate data sharing and collaboration across projects, and help ensure that time, effort, and scarce resources are expended wisely.

The authors of the chapters are acknowledged within the report. In addition, a list of all the scholars in our video research "community," both those who contributed to this document through their participation in the conference and those who came together for subsequent meetings at which this document was vetted, is included as Appendix C.

2. STRATEGIES FOR VIDEO RECORDING: FAST, CHEAP, AND (MOSTLY) IN CONTROL

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In this section, we[2] provide guidelines and strategies for producing, indexing, and analyzing video recordings used as primary data in studies of learning and teaching. Our purpose is to describe a set of resources for researchers interested in conducting detailed analyses of learning and teaching, whether in schools, workplaces, or other settings where video recordings can provide dense, close-to-reality information about ongoing human activity. Our methodological framework combines micro-ethnography and interaction analysis (e.g., Jordan & Henderson, 1995), although the data-collection strategies discussed are also appropriate for other analytical frameworks (Barron & Engle, this volume). We do not propose *the* definitive method for capturing video data, but we do mean to include crucial practical details for doing this work that are often lost in graduate-level qualitative or interpretive methods courses (even in the way that we teach them). Rather than erect a boundary around some intellectual terrain defined as a method, our goal is to collect these details in a form that will enable stronger, more strategic field studies of learning and teaching.

Video recordings are increasingly being used as primary field materials that are later treated as "data" for particular research questions (Erickson, 1982; 1986; 2006). The rapidly expanding technical practices of such work should be anchored in systematic, established field research methods that have been developed by and taught to educational researchers over the past several decades. Slightly updating Schatzman and Strauss (1973), we propose the following heuristics for conducting fieldwork that includes collection of video and audio recordings:

Conduct fieldwork strategically. It is important to have a plan, but it is equally important to be responsive to what you find. Revisit your plans in relation to your questions as fieldwork unfolds, both in the interactional real-time of recording events and across the local history of events seen as you step back to view the progress of your study.

[2] The use of" "we" as a collective pronoun in this section reflects ongoing conversations with Reed Stevens (University of Washington), Ann Ryu Edwards (University of Maryland), Tony Torralba (University of Hawaii, Oahu), Susan Jurow (University of Colorado, Boulder), and Frederick Erickson (University of California, Los Angeles). Erickson and Hall conducted an NSF-sponsored workshop on analysis of video recordings at the 2004 International Conference of the Learning Sciences, then again for doctoral research fellows in the NSF-funded Diversity in Mathematics Education Center for Learning and Teaching (2004). We have also benefited from suggestions by Roy Pea (Stanford University) and Timothy Koschmann (Southern Illinois University).

Treat yourself as a recording device. Your experience in the field is important, but what you bring back from that experience and its utility for later analysis are equally or more important. There are two practical aspects to fieldwork. First, you should capture what is happening, as best you can. Second, you should provide an index of these recordings that will later allow you to locate particular events or utterances in a (probably) rapidly growing collecting of such recordings. Having an experience that is not captured or even a reversible chain of notes and inscriptions is (for our purposes) much less valuable than having an experience you can later document vividly, using materials other than your own (selective, maybe even romanticized) recollections.

Separate observations from inferences. If the materials you collect in the field are later going to provide information that you treat as data for a research question, you will need to distinguish between *what* you observed and *how* it unfolded (both candidates for observational notes), on the one hand, and *why* it happened in a particular way or *what* it means (both candidates for analytic notes), on the other. Given that your capacity to remember what you saw or heard will quickly be overwhelmed by the volume of information you encounter in the field, you should treat your writing in the field as an archive that distinguishes between analytic and observational notes.

Build your analysis incrementally. It is not likely that your final analysis, or even the phenomena described or explained in that analysis, will strike you immediately, while you are engaged in doing your fieldwork. You will be busy writing down what you notice, creating a carefully indexed structure that will provide future pathways into the dense sources of information you are collecting (e.g., audio or video recording, use and production of documents), and making sure that the sampling scheme implemented by your recording equipment is being strategically “wrapped around” the unfolding action (e.g., you may need to reposition audio or video sources as people move).

It may seem contradictory to recommend that you think of yourself as a mechanical recording device, on the one hand, but also remain adaptively open to finding things you might not have imagined while planning your research, on the other. Yet this is exactly the dilemma of fieldwork. What turns out to be “most important” for your analysis might not present itself clearly as you are in the field but instead might occur to you later, as you fill in gaps in field notes and in content logs of audio or video recordings. Thinking about your experiences later is a form of remembering. Having a way to index high quality recordings of activity is an enormous prosthetic extension of memory, inference, and analytic imagination. Our proposal for how to handle this dilemma of being methodical about collecting information while remaining open to unanticipated experiences is to think about expanding the temporal horizon of fieldwork: Time spent in the field should always be organized with an eye to the future, to what can be analyzed in some other time and place. This idea influences the management of one’s attention and the organization of the often difficult work of making field notes and collecting other information that becomes available during the activity being studied.

One can and should make plans and attempt to follow through on these plans when in the field. But effective fieldwork is always strategic and responsive, simultaneously consisting of working to collect information that can later be used as data for pursuing research questions and of being open to the unexpected in ways that will shape what can be asked and answered during later phases of analysis.

MINIMAL VIDEO AND AUDIO RECORDING EQUIPMENT (AND BEYOND)

The widespread availability of relatively inexpensive consumer digital video (DV) cameras makes it possible for researchers conducting even small research projects to collect very high quality video and audio recordings. In this section, we start by describing a minimal equipment rig that should allow a researcher to be fast, cheap, and (mostly) in control[3] while collecting these recordings. The following list includes suggestions for one such rig.

Camera. A mini-DV camera should have an image stabilization feature (for hand-held use) and true stereo (left/right) audio separation. A rechargeable, long-life battery (i.e., one that will last more than three hours) is also highly desirable. A good quality, screw-on wide-angle lens is also very useful, particularly when the researcher is filming in restricted spaces. Use a camera into which tapes can be loaded while the camera is attached to a tripod.

Microphones. Several types of mics are useful. Almost any external mic will do a better job of sound capture than will the camera's built-in mic. *Directional* or *shot gun* mics, which selectively capture sound from the region toward which the mic is pointing (sound from the side is suppressed), can be mounted on the camera. *Boundary* or *pressure-zone* mics are usually placed in a fixed location and capture a wide spectrum of sound (not selective). *Lavaliere* mics are usually pinned to a speaker or some other object that is moving and will be close to sound sources you would like to capture. All of these types of mics come in battery-powered models that can send signals to receivers (also battery-powered) that plug directly into the camera. It is also good to purchase high-quality mics (e.g., with xlr connections, which must be compatible with your camera, and adjustable wireless frequencies). Consulting an audio expert may help.

Tripod, earphones, gaffer's tape, and camera bag. By attaching your camera to a good quality tripod, you will be able to smoothly pan and zoom (see below) and lock the camera in a fixed position when you are busy with other things. It is vital to check your sound with earphones at the

[3] From Errol Morris' unusual film, *Fast, Cheap and Out of Control* (1997), we want to borrow the obsessive quality of pursuing technically and ethnographically adequate field video recordings, while holding out for the possibility of staying *in* control.

beginning of a recording and again periodically while recording. A video record with weak or compromised audio will be of little use later. Gaffer's tape (black, cloth tape) will allow you to tape down the legs of the tripod (and anything else you don't want to send crashing to the floor) without leaving marks on furniture or other anchoring objects. A durable, spacious camera bag should allow one person to carry the entire rig in one hand while carrying a tripod in the other. This kind of rig can be treated as a unit, and as you take more units into the field, your options for capturing multiple video and audio streams increase accordingly. Later in this chapter, we discuss at greater length the use of multiple cameras.

Equipment for capturing video and audio is becoming increasingly sophisticated and specialized. As one example, on the NSF-funded Deixis Project (http://www.siumed.edu/call/index.html), Timothy Koschmann uses head-mounted and fiber-optic cameras to capture surgical procedures conducted in a training hospital. These types of cameras, though expensive, have the feature that they must be operated by study participants to find and manipulate relevant structures (e.g., a vein) in the teaching and learning events being investigated. This feature has the advantage of revealing exactly the focus of the participant's attention. As a second example, on the NSF-funded DIVER Project (http://diver.stanford.edu/contact.html), Roy Pea uses a set of five cameras to collect a 360-degree record of some activity. After intensive post-filming production of the video and audio record, the DIVER environment provides a set of Web-based exploration and annotation tools that allow multiple analysts to make selections from the panoramic record and share their in-progress analysis. As a third and final example, Reed Stevens has created a set of software tools called Video Traces (http://faculty.washington.edu/reedstev/vt.html), which allow people to layer voice and icon-based pointing and tracing over the surface of existing video recordings. These traces (recordings with annotation layers) can be shared between members of a technical community (e.g., dance choreographers, sports teams) to support diverse learning and teaching practices.

These three examples use tools that are much more elaborate than our recommendations for a minimal camera rig, but they hint at the range of possibilities for using video recordings in educational research. Even as technological advances make it possible to bring more video and audio sources together in a set of recordings, there will always need to be some strategy for allocating resources to sample from the activities under investigation, whether at the time of recording or later in the analysis process (see next chapter on "Selection" in this report). Most situations in the field (or in many laboratory studies) are infinitely complex. With multiple camera rigs, you must choose what to capture and bring home at the time of recording.

CAPTURING RELEVANT PHENOMENA IN VIDEO AND AUDIO RECORDINGS AS A SAMPLING PROBLEM

The most common scenario in studies conducted in classrooms or workplaces is to capture video and audio using a single, consumer-grade video camcorder. The recording necessarily shifts among activities with very different participation structures (e.g., group presentations to a whole class, whole class discussion, or small group work). The activities to be captured are internally complex, but a single camera recording will inevitably fail to capture much of this complexity. This does not mean, of course, that researchers need to pre-parse the activity into disconnected bits, use panning and zooming wildly to follow conversations, or turn the camera on and off to eliminate activity they expect will later be of little interest (all are done, unfortunately). For all the reasons discussed at the beginning of this section (see also below), such techniques, which introduce radical discontinuities into the video record, are a bad idea. Instead, we highly recommend that when a researcher is using a single camera, the researcher should make continuous recordings and use panning and zooming carefully (even minimally). Tape is cheap, in comparison with the cost of your attention processes during recording. Also, your ideas about how to parse activity at the time of recording (turning a camera on and off, panning and zooming) may rule out lines of analysis that you (or your colleagues) discover and would like to pursue later. If you are operating a single camera, and you must follow action that is dynamic, consider a technique like that depicted in Figure 2.1 (below), an example in which zooming is used to capture talk about media, and panning is used sparingly.

When the activities you want to capture are especially complex, you should consider using more than one camera. With two camera rigs, the researcher can distinguish between "wide" and "follow" perspectives and can treat each camera as a different point of view and also use L/R separable stereo sound to capture multiple mono-audio sources (four separable audio sources with two cameras). Using only two cameras, the researcher has a relatively large capability and flexibility to capture even complex field situations. Allocating two video and four audio sources becomes a sampling decision (Hall, 2000). If you have a strong theoretical model of the phenomenon you want to capture, you can allocate these sources more precisely. If you are less sure of the phenomena of interest, you will want to allocate sources to maximize your chances of finding interesting things as they emerge (and are noted by field observers) or in later, more exhaustive (and exhausting) analysis.

Below, we describe two sampling strategies, both involving more than one camera.

For contexts in which multi-party talk and work with physical artifacts is all contained in a small space, use two cameras. A "wide" camera captures the whole scene. The wide camera can be fixed on a tripod, high and in the corner of the room (perhaps using a screw-on, wide angle lens), with mics (audio sources) placed near the center of the space where most talk will occur. The wide camera is typically not maneuvered (although it could be) but instead is set up and run continuously to capture an outside-in view of the whole scene and audio environment.

A battery-powered "follow" camera can be either tripod-mounted or hand-held (with image stabilization turned on), using two wireless lavaliere mics placed on people who will be likely speakers (or will be in the action you want). The mic receivers can also be battery-powered, and each receiver will contribute a mono-audio source into separable L/R stereo audio tracks on the follow camera. The person operating the follow camera moves through the action, panning and zooming so as to capture activity that can be analyzed later (more on this in a moment).

It is important to start all cameras before the action begins, to record continuously, and to continue recording until people have left the scene. As pointed out by Jordan and Henderson (1995) and many others, small talk that occurs as an activity starts or ends is often tremendously revealing about how participants interpret the events depicted in the video record. Operating a follow camera is a full-time job, but manning a fixed camera allows a single-handed researcher to write field notes using time indices taken directly from the camera (e.g., by noting time in the viewfinder). It is also possible to have a researcher seated next to a fixed camera, with earphones on to allow hearing of what is being recorded and (if necessary) a video feed going to a small monitor to allow the researcher to see what is being captured. This person could be typing observations into a laptop computer, and the person could even use the wide camera's remote control to zoom in and out (e.g., when rigging the camera, set maximum zoom on some object whose details matter, like a computer screen or text, then zoom back to wide).

There is considerable controversy over whether camera operators should use panning and zooming. If researchers want to understand integrated social activity, they should not focus only on a part of that activity. For example, if people are working to construct or to make sense of something on a computer screen, it is not useful to capture only the screen. Likewise, since much of the participants' talk will be indexed to the computer screen and its objects without full description, neither will it do to capture only the people, and later to be unable to distinguish any particular object on the screen. The job of a person operating a follow camera is to stay with the *proxemic shape* of the interacting group (i.e., bodies in relation to each other and things), ideally keeping everybody in that group within the visual frame as they move around.

For example, a follow camera operator can attempt to have speaker and listeners in view as a speaker is making some point primarily with words. The reason for wanting to have the participants' faces and bodies in view as much as is possible is that analysts will want to determine what people orient to in conversation (where gaze is allocated, how bodies are coordinated with media, etc.). But when the speaker begins to open a document to point out what he or she is talking about, or begins writing on a white board or sheet of paper, the follow camera operator can begin alternating between zooming in close to get the artifact-level details and zooming back out to get speakers and listeners. As a way to capture aspects of context that are (presumably) available to study participants, zooming in and out of the scene is preferable to panning across speakers and media. This technique is illustrated in Figure 2.1.

FIGURE 2.1. ROW 1 SHOWS TWO FRAMES FROM A STATIONARY WIDE-ANGLE CAMERA. ROWS 2 AND 3 CONTRAST TWO DIFFERENT RECORDING STRATEGIES FOR THE SAME TIME PERIOD BY A FOLLOW CAMERA.

As illustrated in rows 2 and 3 of the matrix in Figure 2.1, a follow camera can be zoomed in and out to capture details of talk about representational media, whereas a wide angle (row 1) on the conversation alone would not allow an analyst to recover the content of speakers' utterances. However, panning to capture head shots in conversation is discouraged (row 2). A more skilled camera operator (row 3) might stay at wide zoom when conversations are underway, zoom in tight to capture gestures by Speaker 1 that are coupled to documents, and then return to wide zoom as the conversation continues with Speaker 2 taking a turn. The result (second row of lower matrix) preserves much of the interactional context but still allows an analyst to recover what is being talked about (or produced) in the media. It can be difficult to operate a follow camera in this way, but it is a technical practice that can be taught and learned as a basic part of field research methods and that improves with experience.

For contexts in which there are multiple, local scenes of multi-party talk running in parallel, with periodic public talk at a "center," use more than one camera. In many classrooms, researchers want a good recording of the teacher's actions and talk, and this can be captured using a camera in a fixed position (e.g., in the corner of the room, facing away from windows), a wireless lavaliere mic on the teacher, a directional mic attached to the camera (or a boundary mic in some strategic location), and a camera operator whose job it is to capture the proxemic shape (see above) of the teacher's activity. This is a full time job when a teacher is physically active, moving around the classroom to visit local groups working on problems together.

At the same time, the researcher can dedicate one or more cameras to local groups. All these cameras can run simultaneously, or the local camera(s) can move across groups to capture fixed intervals of time (again, a sampling scheme for what to record). This recording strategy will allow weaving together local and whole class contexts in a way that might allow an analyst to follow the movement and development of an idea in multiple directions. For example, the analyst could track ideas or utterances contributed by the teacher in public talk into local groups (sometimes with spectacular transformation), and could also follow ideas or utterances by students or teacher in local contexts back out into public talk (again with transformations).

Some fieldwork sites that contain multiple, simultaneous streams of multi-party talk have no physical center because the parties are located in different physical spaces, and yet participants do manage to coordinate their activities in real time. Examples of such sites can be found in Ed Hutchins' studies of distributed cognition in ship navigation (Hutchins, 1995), Lucy Suchman's studies of flight operations at a major airport (Suchman, 1997), and Charles Goodwin's (1995) study of oceanographers dropping instruments into a water column. In all these studies, multiple video and audio sources were captured and then synchronized during analysis. We do not consider video recording of such fieldwork sites in this section.

As a final comment on making continuous video and audio recordings of complex activity, it is important to realize that the resulting records may not have production values that would equate with typical film or television production values, and so they may be very difficult to watch for people who are used to seeing human action depicted in television or documentary narrative formats. This should not be a problem for researchers or their sponsors. Staging educational scenes with high production values should be understood as video work with a different goal: one that more resembles movie-making than capturing sources of data for educational research.

We now turn to what will be done with video recordings as they begin to accumulate for days, weeks, or months. Just as one must be strategic when deciding what to record, one must also be strategic about indexing these records, because piling them in a box or storing them on a mass storage device simply defers the work of finding phenomena that are relevant to your research question.

INDEXING VIDEO (OR AUDIO) RECORDINGS FOR LATER ANALYSIS

Schatzman and Strauss (1973) are again helpful by providing ideas about how researchers can create index structures for recordings so that the analyst can find particular events or phenomena of interest without having to view the entire collection of tapes (or files). You will want to be able to quickly and easily coordinate time-stamped field note entries with locations in your video and audio recordings to which those entries pertain. If field observers make time-indexed observational notes as recording is in progress (e.g., 09:43 followed by a description of an event noticed at 9:43 a.m.), these notes can be collected in a searchable database. That database, if constructed properly, can provide a focused and efficient way of retrieving video segments or episodes that correspond to written descriptions or illustrate categories being developed in an analysis.

When capturing video recordings and writing field notes, it is important to think about likely contexts of analysis that will occur later. For example, you might imagine sitting at a computer projecting video onto a screen, working on field materials with your collaborators. You will probably want to be able to find and play a video episode of some event of interest for discussion and analysis in a project meeting. You might want to be able to quickly and easily find this event again months or years later, using a time index contained in the original field note collection or in a file containing subsequent annotations and analysis.

Although the problem above sounds straightforward, there are many ways to lose your way. For example, clock time written on field notes will function as an index to digital video only if it helps you go directly to the event of interest during play back. The accuracy with which you should be able to quickly locate a video segment should be within one minute, although a couple of seconds is much better. If the video record is continuous, it is relatively easy to calculate elapsed time from the beginning of the record to find the event, even if the digital recording cannot be indexed directly by clock time. However, if the video recording is not continuous, you may not be able to coordinate clock time in written notes with elapsed time in the digital recording. Given the pace of discussion and analytic work in a typical research team meeting, repeatedly stopping to find your way can derail productive analysis.

If a researcher synchronizes cameras, starts multiple recordings at the same time as much as possible, includes some reference event when starting multiple recording devices (e.g., a loud clap or an initial focus on a common clock), makes continuous recordings, and time-indexes written field notes in a way that is coordinated with the multiple recordings in progress, any field note should be able to serve as an index to some recorded event. These steps will allow a research team to pool field notes into content logs, to share annotations, and, during meetings, to quickly find a particular event that people want to talk about.

However, these steps will facilitate the research team in this way only if video recordings and field notes are placed into some kind of archive relatively quickly during or immediately after collection. If you are collecting only a few hours of film from a single camera early in the week, and you want to be able to use field notes to access these recordings in a research group meeting at the end of the week, your task is very simple. Researchers can select discussion-worthy events from time-indexed field notes before the group meeting, and can have digital video available to look more closely at indexed events. This assumes that the digital film can be placed on-line within a couple of days. (The capture and compression of miniDV to a format like MPEG4 is a "black box" we do not open in this section.)

As a final note on strategies for recording with an eye to later analysis, there are accounts in the published literature in which researchers claim to be able to analyze video and audio recordings on a time cycle that allows them to make instructional decisions based on these recordings the next day in a classroom. Particularly for matters that require close analysis, it is not likely that anything substantive found in a video recording could be understood well enough to be useful, for instructional design purposes, the very next day. The issue is that of the pacing of analysis in relation to design. Researchers may want to plan an analysis-design cycle into their projects at the outset. One part of this planning is to develop a working infrastructure that is quick, flexible, and robust. Another part is to set aside in the schedule time for analysis, particularly in situations in which the results of that analysis are intended to be used to guide instructional design. More importantly, think carefully about how to allocate funds to technical infrastructure, to recording equipment, and to time for analysis on research projects. If you are under pressure to trim costs, there is nothing very clever about trimming your equipment and time budgets in the areas of recording, event logging, transcription, and digital archiving. You'll find yourself out of time and out of money but still responsible for the research.

3. SELECTION IN VIDEO

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Accessible video technology provides researchers with a powerful "microscope," greatly increasing the interactional detail that can be recorded and permanently stored for comprehensive analysis and reanalysis by multiple investigators. However, this enhanced observational power requires thoughtful attention to the problem of how to extract data and meaning from complex video-based corpuses. This particular case of *data selection* – a process of focusing on particular information in accordance with the theoretical frameworks, research questions, and instruments a researcher chooses – happens at different times: before video collection (during study design and planning); during collection (as interim and early analyses are carried out); and after video collection (as more detailed analyses and final products are developed).

What follows is a discussion of *selection* as an overarching construct for educational research in which video is used as the major (although almost never the only) information source. The question we consider is how to be systematic rather than arbitrary and capricious when selecting with video recording devices and from the video recordings they create. We first address how to conceptualize the nature of what is selected. We then discuss selection at different stages of inquiry, distinguishing between two fundamental purposes for making video selections: depicting or telling a narrative account of some phenomenon; and creating a source for information storage and retrieval that will support the identification and analysis of data. In regard to the latter we distinguish between inductive and deductive approaches, distinguishing both from narrative-evolving approaches to video selection. A complicating factor we acknowledge is that the different purposes and approaches can overlap: sometimes they are combined in one project, and sometimes good video research represents work on the borderline among them.

CONCEPTUALIZING THE NATURE OF WHAT IS SELECTED FROM VIDEO

What entity is created when particular elements from complex events captured on video are removed from their larger contexts and become "clips" for further use, including detailed examination? There are various ways to conceptualize the video clip, but one useful perspective from perceptual psychology (Zacks & Tversky, 2001) is that video segments represent *events*. Any video corpus contains many events. Selection determines which events are brought into focus for deeper analysis.

Events are time-analogs of objects. Like objects they have underlying structures reflecting multiple parts and timescales (Lemke, 2002). To illustrate, consider a classroom event during which students collaborate on the interpretation of data presented as a histogram. This event could be parsed in terms of various sub-events, for example: the presentation of an idea by a student; the response by another indicating acceptance, confusion, disagreement, or even disengagement; periods of negotiation through which joint understanding emerges; etc. These sub-events might be further analyzed as coordination of even smaller events on smaller timescales: gestures, speech, tool use, mental states, etc. Or, the entire classroom event could be considered to be part of a longer-term macro-event, such as the development of students' ability to read and interpret a range of data representations from various sources.

The ability to decompose a complex event and select specific parts to pay further attention to is influenced both by a researcher's perception and by what actually occurs. Psychological studies show that people "see" events similarly, in terms of causal, behavioral, and thematic structures, although expert ways of interpreting events, of "seeing in depth" (Goodwin, 1995), develop through specialized training and experience. Observed changes in types of behavior (e.g., laughing versus talking), physical direction (turning toward the exit), the object of behavior (child puts down pencil, picks up toy), setting (in the dining room versus in the kitchen), and tempo of activity (jogging versus cool-down phase) determines how people see and interpret events as chunks of time. The trained observer can reasonably conclude: The theme of this chunk is doing math, I'm interested in that; that one is mostly about *play*, I'll discard that chunk. However, this one is both *play and doing math,* and so I'll look at it.

The researcher's specific interest will determine which events and which timescales a study should select. For example, if the researcher is interested in studying the coordination of the cognitive, material, and social processes through which understanding of the concept *variable* first arises, an appropriate plan would be to begin by recording, or by identifying in an appropriate set of previously recorded data, problem-solving situations in which children encounter this concept and the concept is first developing. A reasonable timescale for each selection would be the period in which a child encounters, grapples with, and resolves a problem involving variables. However, if the interest is in studying development of how students acquire a more inclusive concept (such as the histogram) as a representational tool, then the researcher must focus on a larger event, including antecedents occurring over a longer timescale. The selection strategy in the latter case would consist of strategically sampling important sub-events that represent key points within a larger developmental timeframe.

STAGES OF INQUIRY AND SELECTION

Event selection occurs at all stages of the inquiry process: (a) planning a study and making certain decisions about what, when, where, and how to shoot; (b) shooting original footage (turning the camera or cameras on at some juncture and off at another; shooting mainly wide-angle or mainly close up; panning and zooming, in what is called "camera editing"); (c) choosing one or more clips from a corpus of such footage; and then finally (d) focusing on the selected video clip or clips differently depending on two different goals of recording: 1. presenting events more or less holistically as examples, anecdotes, or vignettes that tell or illustrate a story; or 2. using the selected clip or clips as information sources from which to generate data through various kinds of transcription and analyses. The case of creating highly "produced" educational videos is different and is only briefly addressed in this report as part of the chapter, "Research on How People Learn With and From Video" (Sherin & Sherin, this volume).

Ideally, selecting video from a larger corpus of information will proceed differently at each stage, depending on whether the outcome one has in mind is narrative, data mining, or both. We use the qualifier *ideally* in recognition that researchers do not always carry out selection or have control over selection at each stage of research. For example, in his study of the Rodney King incident and trial, Goodwin (1994) analyzed *available* video of the incident. Although a researcher can conduct good research with repurposed video that was not collected with concern for this researcher's goals, the researcher must consider how selection at previous stages affects analytical possibilities when video is used, as illustrated in Leonard (2006).

PURPOSES OF VIDEO SELECTION

The vast majority of educational research using video has involved identifying and analyzing data within selected clips. Researchers selecting video clips for this purpose are often concerned with closely describing and accounting for the relative frequency of a type of event. They may need to determine an event's typicality or atypicality and the distribution of its occurrence: For example, does event X happen only in the classroom or also at home and in after-school settings? Within classroom type A (a math lesson), where and how often does event X happen? Does phenomenon X happen in every videotaped instance of classroom type A or only in some instances?

These questions about distribution and relative frequency are forms of inductive contrastive analysis in the general spirit of well-known qualitative approaches such as Strauss's (1987) *constant comparative method*. A famous example of inductive contrastive analysis in the educational literature is Hugh Mehan's (1979) analysis of question-answer sequences in whole group lessons in inner-city elementary school classrooms, published in *Learning Lessons*. Mehan videotaped lessons in a range of subject areas during an entire school year, transcribed every lesson, and then identified every question-answer pair and every topically-tied sequence of such pairs. He then showed that the vast majority of the instances were of the three-part sequential "I-R-E" form: initiation by the teacher (by asking a question the teacher knows the answer to), response by the student (saying something related to the question), and evaluation by the teacher (concerning the correctness or appropriateness of the student response). What Mehan did that was methodologically rare at the time was to perform an exhaustive, contrastive analysis on an entire corpus of instances. Every instance of a question-answer sequence in his data set was accounted for analytically. The "data" were obtained by coding, according to its I-function, R-function, and E-function, every transcribed turn of speech in every transcript Mehan had.

VIDEO AS DATA

It can be argued that Mehans' minimally-edited video was not automatically data but more appropriately should be characterized as an information source within which data could be identified. To create data, the researcher strategically selected video segments from an available corpus and used them for a specific analytic purpose. Such purposes differ in accordance with the theoretical orientation and research questions of the researcher. One researcher may select and examine a clip to extract data on mutually influential relationships between the talk of the speaker and nodding reactions by the listener, as did Erickson and Shultz (1982) in *The Counselor as Gatekeeper*. Another person could be studying the same video to identify *implicit discourses* – value assumptions and student identity definitions – as part of the so-called hidden curriculum, as Jay Lemke did in his study of science classrooms (2001). Or the researcher might select clips that provide data on students' transcription practices (Lehrer & Schauble, 2004), or teachers' representation and modeling practices in design-based science (Leonard & Derry, 2006), or scientific terms in the individual speech of students in small groups (Lynch, Kuipers, & Pyke, 2005). In all these examples, selected video was mined by analysts for data that could be identified using various formal analytic and transcription procedures. Video became data *after* emergent analytic frameworks were developed and systematically used and worked out across multiple viewings (Goldman & McDermott, 2007). Not until the recorded discourse was dissected and aligned with researchers' methods of representing participants' behavior did the researchers' opinions and biases from initial viewings evolve into empirically valid accounts.

SELECTING FOR NARRATIVE POWER

In selecting a clip to tell a story or a piece of a story or to show what an instance of event phenomenon X looks and sounds like, the researcher looks at video recordings to find the "best" instance or instances of X – perhaps the most dramatic clip that best illustrates and represents X and is the clearest of those available in picture and sound. A clip chosen for purposes of representation or story telling is not primarily selected for its adequacy to support analyses that will provide evidence about relative frequency of a particular type of interactional phenomenon (e.g., a kind of utterance, gesture, or math reasoning). The clip may help *define* an interactional phenomenon under study and may even be a representative case of it, but it is selected largely because of its qualities as an example.

Some digital ethnography research takes a narrative perspective in which selection is directly related to the process of creating a story as it evolves in the mind of the researcher. The researcher may select interesting and illustrative video segments soon after they are gathered throughout the study or at regular intervals. The study is influenced by this continual and interactive process of building the researcher's knowledge in much the same way that a director of a film watches rushes and makes selections of best takes. The study changes during the process of selection, which sharpens the "eyes" of the researcher. As selection proceeds throughout the project, the researcher is making decisions about why to choose one segment and not the one before or after, in accordance with a narrative structure that is emerging. This approach to selection differs philosophically from ones in which researchers strive, using minimally-edited video footage, to sample events as information sources.

To help distinguish the narrative functions from the data mining functions of selection, one can ask whether the goal is (a) selecting events that best showcase or illustrate particular ideas or concepts or a researcher's evolving interpretive narrative, or (b) systematically selecting representative clips to help identify and document some naturally-occurring pattern. Another rule of thumb is to determine the extent to which dramatic or aesthetic criteria are being considered. In choosing a clip for its illustrative or narrative potential, what the clip looks and sounds like and its overall appearance according to aesthetic criteria may be of foundational interest and largely govern the selection. In contrast, when choosing a clip for its potential as a source of data that will be mined by researchers using coding and analysis procedures, what the clip looks and sounds like is not a major determining factor for selection, and such considerations might even bias the research. This does not mean that data-mining researchers should ignore technical considerations that determine the quality of their sound and picture. But picture and sound that are visible and audible may be "good enough," aesthetically speaking, for data mining.

Projects in which narrative and illustrative concerns are at the fore are exemplified by teacher professional development Web sites such as TEACHSCAPE, http://www.teachscape.com/, in which developers make available exemplary or illustrative video cases of teaching practice. Other examples from teacher professional development are the case studies of student thinking selected for "Seeing the Science in Children's Thinking" (Hammer & Zee, 2006). The video collection located on a Web site cross-referenced to the book *Points of Viewing Children's Thinking* (Goldman-Segall, 1998) represents an especially original example of digital video used in this manner. The Carnegie Foundation's KEEP Web site, http://gallery.carnegiefoundation.org/, on which teachers post thoughtfully-developed cases of their teaching scholarship, illustrates selection of video to support personal narrative.

COMBINING PURPOSES

Although drawing a distinction between these two purposes of video selection is conceptually useful, a complicating factor is that they represent fuzzy, overlapping categories that are frequently combined. For example, in his book *Talk and Social Theory* (2004), Erickson used both kinds of selection simultaneously. He presented four video examples on a Web site – one for each of four chapters in his book. These clips served as illustration and narration. But they were also treated analytically (and micro-analytically) in the book chapters, with transcription of verbal and nonverbal behavior presented in differing grain sizes and supporting discussions of issues at differing timescales.

The TIMSS video project (Stigler & Hiebert, 1999) represents an additional way in which the two categories of selection overlap conceptually. The huge TIMSS video corpus has been selected from for professional development purposes and to support cross-cultural studies of teaching. But *sampling representativeness* has been an overriding concern in selecting for both purposes. In the TIMSS project, a formal sampling logic governed the selection of video in stages of research that occurred before recording (planning what countries and schools to sample). During recording, rules for sampling behaviors guided the video selection that occurred at camera-editing time: the camera operator was instructed to adopt the perspective of a "good student" paying close attention to what was happening in class. Even in situations in which developing a narrative is the main goal of selection and aesthetics are of fundamental importance, issues of selecting *fairly* to represent culturally prototypical cases of practice have come to the fore. A good illustration of this issue is discussed by Miller and Zhou (2007), who describe a decision to stop showing aesthetically and conceptually pleasing clips of mathematics teaching in Japan when it was discovered that the methods illustrated were considered outdated and atypical of current teaching in Japan. A similar illustration is found in Tobin, Wu, and Davidson (1989), who videotaped preschool classrooms in three countries and produced edited videos depicting a "typical day" in each setting. They then showed them to teachers and principals in each country for confirmation that the events shown were typical and representative. Where there were disagreements about what was representative, these were described in the video cases.

These examples help lead to an important point: When researchers collect video that will become a public corpus or that will later be shared and selected from by other researchers or even used again later by the original researchers, the original researchers will not, at the time of collection, have anticipated all potential and future uses of the video. To help ensure that future users of video will not inadvertently commit errors of selection bias – for example, treating a video corpus or clip as though it is a representative sample of practice when it is not – it is necessary to fully document archived video images with information about when, where, and how they were collected. Such documentation should permanently live with the video corpus and be available to and used by researchers who later select from it. A good discussion of what data should live with video collections is found in Clancey (in press) and is discussed briefly in the chapter in this volume on recording (Hall). However, documenting a video corpus raises numerous concerns, as described in "Ethical Concerns and Video Data Collection" (Derry, Hickey & Koschmann, this volume).

Another type of combining of narrative with data-mining purposes occurs when video clips that are originally selected to support narrative story telling and may be non-representative samples are subjected to deeper analysis. Here we refer to scientific analyses of video performed by researchers, distinguishing these from less-formal analyses of the type conducted by teachers who participate in lesson study or video clubs, which are discussed in the chapter on learning with and from video (Sherin & Sherin, this volume). The practice of analyzing "interesting" video clips without making strong claims about what categories of phenomena these clips represent more broadly is supported by an alternative viewpoint toward selection held by many conversation analysts: that at this point in the study of human social interaction, we know so little that we should, as a matter of principle, presume that each thing that happens interactionally is of equal potential interest and importance. This approach places few constraints on selection: almost any minimally camera-edited video clip of human social interaction is worthy of being investigated. While this arguably may be an acceptable notion of validity, it is a very different perspective from that held by researchers whose selection heuristics are guided explicitly or implicitly by probabilistic concepts of frequency and representativeness. From the probabilistic view, which is widely accepted in the scientific community, a minimally-edited video clip that might be used to support a narrative account is suitable for analysis only if it can arguably be regarded as a representative case of phenomena the researcher wants to study.

SELECTION STRATEGIES

In conclusion, we distinguish among three ways of thinking about video selection: inductive, deductive, and narrative-evolving. Inductive approaches most clearly apply when a minimally-edited video corpus has been collected and is being investigated with broad questions in mind but without a strong orienting theory. One generally begins by viewing the corpus (or as much of it as possible) in its entirety, then studying it in progressively greater depth for the purpose of identifying major events and characterizing the hierarchical event structure of the corpus as a whole. The appropriate timescales for event segmentation will vary, depending on the training and interests of the researcher. The whole-to-part inductive procedure described by Erickson (2006) recommends repeated viewings in which multiple viewers reach agreement on major events, transitions, and themes. Abstract "intermediate representations" that describe the corpus as a hierarchical macro-event may be developed (see Barron & Engle, this volume). Such intermediate representations can help researchers strategically select events for analysis that adequately cover major themes and include key participants and hence constitute a kind of representative sample from the macro-event. The conversations and non-verbal behaviors from such a sample are transcribed, becoming the selection for deeper analysis.

A deductive approach is required when the researcher has a strong theory and clear research questions. Deductive approaches involve identifying or creating a suitable video corpus and systematically sampling from it to examine specific research questions. For example, Alibali and Nathan (2007) examined how a teacher used gestures in explaining mathematics to middle-school students under the hypothesis that gesture is more prominent and important in introducing new topics. They selected video clips in which the teacher either reviewed old topics or presented new ones. Next, they discovered facts about the clips related to the research questions. For example, how many gestures and what types of gestures did the teachers use? Finally, they developed a coding system to categorize the facts and calculate the frequencies of the occurrences, statistically comparing, in this example, "new topic" and "old topic" samples. This coding approach was then used to investigate future samples.

The inductive and deductive selection approaches can be contrasted with those of video researchers who take a more narrative, documentary approach. In Goldman's work (Goldman-Segall, 1998; Goldman-Segall & Maxwell, 2002), for example, selection proceeds during recording as well as during post-recording phases. Such selection is not only intimately intertwined with the researcher's meaning-making processes but also may involve participants as collaborative partners in selection. The study is adapted reflectively as participants are observed and consulted. Or, as in *Points of Viewing Children's Thinking: A Video Ethnographer's Journey* (Goldman-Segall, 1997), the researcher may put the camera in the hands of those being studied, blurring the lines between participant and researcher.

But in *all* cases, choice is a fundamental part of video research. Dewey (1958, as cited in Clancey, in press) argued that selective emphasis is inevitable whenever reflection occurs. Selective emphasis becomes a negative only if, in the researcher's actions, the presence and operation of choice are concealed, disguised, or denied.

4. Analyzing Data Derived From Video Records

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In this section we consider how to conduct an analysis when videotape is the primary information source. We consider planning, theory inquiry cycles, viewing practices, intermediate representations of video records, and ways that researchers use video records to create data and make theoretical or empirical claims. How one approaches an analysis depends crucially on one's theoretical commitments, the specific research questions one is pursuing, and the practical constraints of time, money, and personnel. In high-quality video analyses, the researcher makes a convincing case that his or her analytic choices were sufficiently responsive to these considerations. Reliability and validity issues of all kinds (internal, convergent, external, descriptive, interpretive, theoretical) apply to video-based data just as they apply to any other kind of quantitative or qualitative data analysis. Potential criticisms from the research community about generalizability of findings from video research can be countered by paying explicit attention to the logic of one's inquiry, including one's approach to selecting or collecting records, and by articulating the processes used to create explanations and generate claims. What is clear is that performing analyses with videotape is an iterative process that involves moving back and forth among the videotapes themselves, one's evolving interpretations and hypotheses, and a variety of intermediate representations for discovering, evaluating, and representing them for oneself and others.

Advice Based on Wisdom of Practice

The experiences of researchers using video as a tool for inquiry have yielded a number of concrete suggestions for conducting video analyses that are particularly useful for beginning researchers (Barron, in press). Below we summarize some of these insights and point readers to sources where they can learn more.

Start with guiding questions. Ideally the collection of research video is guided by a plan and a set of research questions that are based on the researcher's familiarity with the phenomena being studied, although situations arise in which video that has already been collected and archived must be analyzed (e.g., Goodwin, 1994; Leonard & Derry, 2006). Such planning is particularly helpful when the researcher is new to video analysis. The amount of detail that can be captured in video recordings makes them a powerful resource when compared to what the human observer can record in real time, but it also makes them challenging to work with. As Erickson (2006) articulates, video records are not data but are resources for developing data. Turning records into data is enormously time consuming. Thus, it makes sense to go into a project with theoretically-motivated questions that originate from the research literature or observations. Good orienting questions help the researcher maintain a perspective that prevents one from getting lost in the details that video records include.

Reflecting on what theoretically-motivated questions might be pursued may fundamentally influence strategies for data collection. For example, many investigators have found it fruitful to combine video records with other forms of data, including data from performance assessments, interviews, and surveys. Field notes, photographs of the surrounding field of action, copies of documents, and products created by groups can enrich the data derived from video records and offer opportunities for triangulation across sources of evidence. The process of developing questions can help focus researchers' attention on what to collect and when. For example, if the question of interest is the role of material artifacts in the alignment of the attention of group members, a plan might include collecting the utilized artifacts or having the camera positioned to film them. As discussed above in the section on selection, research questions will also guide decisions about the sampling of interactions. Anticipating the nature of analyses by crafting questions will also help the researcher create a research proposal and an appropriate budget for doing the work. Crafting good questions is critical for the analysis phase of the research project as well.

Expect unanticipated phenomena. At the same time one is working with guiding questions, it is important to also remain open to discovering new phenomena. For example, Engle, Conant, and Greeno (2007) were interested in conceptual change, and so they designed a data collection plan that included pre- and post-assessments intended to measure changes in students' conceptual understanding, and they collected video data of classroom conversations that were likely to have generated conceptual growth. But during analysis, some totally unanticipated findings emerged. The researchers addressed the good questions they started with, but ultimately the novel phenomena, they believe, were theoretically more fruitful. Formulating and answering questions does not preclude additional discovery-oriented work with video records. In fact, this is one of the valuable properties of video records – they can be revisited, for continued learning and analysis, at different times with different viewpoints and by different researchers.

Develop social practices for viewing. 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 by different research groups. Investigators can strengthen their research findings by coordinating what they learn from multiple viewing opportunities. In the early stages of a video analysis, before interpretations of events become fixed in the researcher's mind, it can be quite helpful to share a key video segment with a group of other researchers to gather multiple interpretations of the events and to brainstorm potential issues to investigate further (Jordan & Henderson, 1995). The video segment can be viewed and re-viewed by the group to look for data consistent or inconsistent with initial hunches. Watching the videotape at a speed that is slower or faster than normal or only listening to the audio or watching the video without audio can also be used to help focus viewers' attention on particular aspects of interest (Erickson, 1982). Group viewing can be used in later stages of work to determine whether multiple researchers notice similar phenomena (e.g., Engle, Conant & Greeno, 2007). Finally, it can sometimes be helpful to have people who were recorded watch the video in the presence of the researcher to provide their interpretations of what was going on. It is preferable to obtain participant involvement as soon as possible after recording and without asking leading questions (Ericsson & Simon, 1980; Jordan & Henderson, 1995).

PRACTICES FOR DATA CREATION AND ANALYSIS

Video can be rich with interactional phenomena, including eye gaze, body posture, content of talk, tone of voice, facial expressions, and use of physical artifacts, as well as between-person processes such as the alignment and maintenance of joint attention (Barron, 2003). Because this complexity makes it easy to become lost in detail, 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 fundamentally different approaches to inquiry. Briefly, he describes: 1. a whole-to-part inductive approach, in which social viewing and re-reviewing are used to identify patterns in data for which there are no strong orienting hypotheses, predictions or theories; 2. a part-to-whole deductive approach, which involves looking for specific types of events and is appropriate when research is driven by strong questions, hypotheses or theories about those events; and 3. a the manifest content approach, in which interaction focusing on particular pedagogical or subject content is selected out and examined. He provides suggestions about stages of viewing, types of summaries to make at each stage, the importance of time coding, 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. There also are numerous other ways to develop an understanding what is on tapes and to build up an analysis. Below we provide additional ideas to draw on.

Representations for Data Selection and Pattern Finding

The creation of intermediate representations of the video records is important because viewing such representations allows the researcher to identify which segments to analyze and to begin to see patterns within and across segments. Making transcripts of talk and non-verbal information is common, and we will share a variety of approaches to this method of representing the content of video records. However, experienced researchers often take other preliminary steps to understand their data set and start the process of pattern finding. Developing preliminary representations can help the researcher decide what should be transcribed and at what level of detail. Below we describe several approaches to developing representations of video data, including transcripts, and the variety of decisions that are involved with each.

Indexing. The first possible time to view 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 while also potentially filling in relevant complementary information that is difficult to discern from the videotape itself. If the researcher cannot be present during recording, it is very helpful if he or she can quickly watch the videotape soon after it was recorded in order to create a content log, which, like the field notes, will provide a time-indexed outline of the events on the videotape. Content logs can be extremely detailed, consisting of a description of major events that took place for each brief standard unit of time (e.g., 3 minutes), 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 the corpus of data and facilitate the selection of episodes for further detailed analysis (Jordan & Henderson, 1995). This kind of indexing should be distinguished from systematic coding. Systematic coding, 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.

Macro level coding. Because transcription is costly and time consuming and not always suited for pattern finding, video researchers often invent ways to summarize records. For example, Ash (2007), who studies family conversations in museums, begins with a representation she calls the "Flow Chart," which catalogues a family's museum visit from start to finish, including any pre- or post-visit interviews that were done. The goal is to mark major events and the occurrence of conversations about biological themes. Topics and themes can be coded from this representation to compare different visits made by the same family or visits made by different families. For Ash, the flow chart representation is also key for selecting the data for her second macro-level unit 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. Ash's final level of analysis involves micro-level examination 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.

Narrative summaries. Other researchers use narrative accounts. For example, Angelillo, Rogoff, and Chavajay (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 one-and-one-half-hour videotaped home visit during which mothers helped their toddlers learn about novel objects. These were not event logs but instead were lengthy (as long as 30 pages) descriptions of events. 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.

Diagrams. Other researchers summarize aspects of video records using still frames or diagrams. For example, in a study that investigated patterns of joint activity between Guatemalan Mayan mothers and children completing puzzles, the researchers' goal was to categorize patterns of joint attention, mutual orientation, and ways of distributing work (Angelillo, Rogoff & Chavajay, 2007). The team created 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 one-minute intervals of video.

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 videotapes proceed, until the transcripts eventually provide a reliable record of what the researchers view as the most relevant aspects of the video for their research questions (e.g., Engle, Conant & Greeno, 2007; Mischler, 1991). 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). Whether explicitly intended or not, the transcript convention employed ends up embodying theoretical judgments about the events that were recorded (Lapadat & Lindsay, 1999; Ochs, 1979). There is no such thing as a "complete" transcript that captures the full complexity of all verbal and non-verbal events. Nor can a transcript be value-neutral.

There are many existing—and in many cases competing—conventions for how one might transcribe different aspects of the social interactions captured on videotape. In Appendix A we have compiled a list of common transcription choices, summarizing their features and their strengths and weaknesses. Appendix A also contains references to work containing examples of these transcription conventions. 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 decisions about which transcription conventions to use make sense, given these various considerations.

MAKING A CASE WITH VIDEO DATA

Because method of analysis and how a video analysis is reported are related, in this section we combine a discussion of analysis and repo and reporting, referring to examples in the published literature.

Play by Play

One common way of reporting a video analysis in a publication is to provide 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 sequentially developing context relates to what happens next. When supported by rich transcripts, these kinds of analyses also are particularly good at demonstrating how multiple actions and people collectively produce phenomena. In one 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 (e.g., Wortham, 2004). Examples of this approach in the published literature include Ochs and Taylor (1996) and Koschmann, Glenn, and Conlee (1999).

Coding, Counting, and Statistical Analysis

Methods of analysis in which videotaped records are coded 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 observed in natural contexts to their colleagues. Systematic observational approaches relied on pre-established coding schemes and were designed to yield reliable judgments by independent observers. For example, early studies of children's play often relied on repeated short samples (Goodenough, 1928), in which a child would be observed for one minute a day and the researcher would code the child's activities into one of six mutually exclusive categories (Parten, 1932). The development of statistical approaches for determining inter-rater reliability was a key innovation. Before video, these methods required that the focus of inquiry and coding systems be fully worked out before data were collected and be simple enough for two or more observers to achieve inter-rater reliability. Video relieves these constraints, allowing analysts to develop complex coding systems over time.

Video researchers develop systems of analysis over the course of multiple research projects. Ash (2007) articulates the changes that have occurred in her coding system and describes the system that evolved, which she calls Tools for Observing Biological Talk Over Time (TOBTOT). Through careful analysis of the talk of families, consultation with biologists, psychologists, and educators, Ash and her team have developed a system that can be used across projects and not only by Ash's team. Ash and her team have gone through more than a dozen iterations to reach what they consider to be a stable and generative analytical system.

Like the processes of generating research questions or creating intermediate systems of representation, the development of a coding approach benefits from iterative cycles of work, distributed expertise, and moving across different levels of analysis. For example, Angelillo, Rogoff, and Chavajay (2007) describe an 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 that is based on the observed phenomena and that can then be applied to multiple cases. They illustrate this approach in their study focused on cultural variations in mothers' and toddlers' 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, the relative reliance on words versus non-verbal demonstration. However, as is the case with many video studies, the interactions caught on video 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 categories so that the phenomena could be reliably coded.

Studies of interactions between mothers and children or between intimate partners provide examples of research based on coding and quantification. Video studies have made important contributions to our understanding of early emergence of sophisticated social awareness in infancy and the bidirectional influences between caregiver and child (Lewis & Rosenblum, 1974). Trevarthen and Aitken (2001) reviewed the important role that film-based studies played in documenting the coordinated interactions of mothers and their infants during naturalistic interactions. Methods of conversational analyses were adapted to provide accurate measurements of the timing of contributions of mothers and infants.

The work on early infancy inspired new analytical approaches such as sequential and times-series methods for describing patterns of adult interaction. In particular, studies of interactional quality among married partners were pioneered by Gottman and his colleagues. Gottman and Notarius (2002) reviewed the progression of research on marital relationships that began in the 1950s, marking the publication of Bateson, Jackson, Haley, and Weakland (1956) on the double-bind as a turning point. This turning point was a shift from personality-based explanations to studies that observed couples in interaction and focused on processes of communication. In the 1970s Gottman developed methods that involved videotaping interactions of couples at a specially constructed "talk table" while the couples also rated aspects of their own communication. This research was aided by other applications of video, namely the study of facial expressions of emotion which led to a coding system called the Facial Action Coding System (Ekman, Friesen, & Ellsworth, 1978). Gottman and Notarius (2002) called for moving research on couples' interactions out of the lab and into the home to provide accounts that are more ecologically valid than lab studies.

Despite the number of studies that use coding approaches, it is by no means universal that data derived from video records are coded in a way that can yield quantitative data. Many researchers prefer to focus on examples (such as in the play-by-play approach) and therefore do not count types of events within or across cases. However, other researchers find coding and quantification useful aspects 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. 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).

Progressive Refinement of Hypotheses

In a recent volume on video analysis in the learning sciences, a number of research groups contributed chapters that include details on their video practices (Goldman, Pea, Barron, & Derry, 2007). In their volume are numerous examples of studies that interweave top-down planned analyses and the reporting of unanticipated phenomena. Some authors describe processes that resemble an approach to qualitative research more generally called analytic induction (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 inconsistencies are found, the explanation is revised.

A similar approach, offered by Engle, Conant, and Greeno (2007), is "progressive refinement of hypotheses." In this approach a general question is framed and records are collected in an appropriate setting. Once records are collected, more specific hypothesis are formed after some viewing of the records. These hypotheses are then examined in relation to other aspects of the data set, and more complete explanatory hypotheses are developed. Engle et al. argue that multiple iterations through hypothesis generation and evaluation lead to greater robustness of findings and increased likelihood that they might be replicated in other contexts.

Reporting Results

Although there have been some attempts to create multimedia journals that could include some video as part of the publication (e.g., Sfard & McClain, 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. Coding and subsequent quantification is a common approach to reporting results. However, although our ability to code behaviors can rest on the well-developed techniques and methods described earlier, there is still the limitation of losing the whole feel of an interaction. Narrative description is another method of representation that better describes interaction; however, narrative accounts are less credible to many experimentally-minded social scientists. One solution to broadening acceptance of a video analysis is to use more than one method of representation when reporting the research. For example, Barron (2000; 2003) used quantitative methods to find response patterns that reliably differentiated among 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, Barron combined what Bruner (1986) described as a paradigmatic approach (coding and statistical analysis) with a narrative approach (which preserved the sequence of interactions). Barron's 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 interacting students at key points.

Erickson (2006) provides a particularly strong argument that readers of analyses should come away not only "tree-wise" but also "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 of how typical or atypical the instances presented are relative to some larger corpus of data. Our discussion has suggested ways of communicating levels of analysis as well as interrelationships among the levels. The problems of re-representing the complexities in video are not trivial, and the video research community is in the beginning stages of figuring out as a field creative ways to do this.

CONCLUDING COMMENTS

In summary, video analysis can range from discovery-oriented approaches, in which the hope is to reveal unanticipated phenomena, to top-down approaches, in which the records are used to identify and code events that have been mostly conceptualized before the data was collected. Researchers starting to plan a project that will use video records should focus first on theory-driven questions and develop concrete plans for a first pass through the video records. Having good questions will help maintain perspective and prevent the researcher from getting lost in detail. At the same time, the researcher should anticipate new discoveries and be ready to articulate questions that can be followed and refined and tested during multiple passes through the video records. These passes can be made most fruitful by using intermediate representations. Researchers should expect to have to engage in multiple cycles of analysis. An explicit multi-stage analytic approach can strengthen the likelihood of generating strong findings that are both reliable and valid.

5. SHARING AND REPORTING VIDEO WORK[4]

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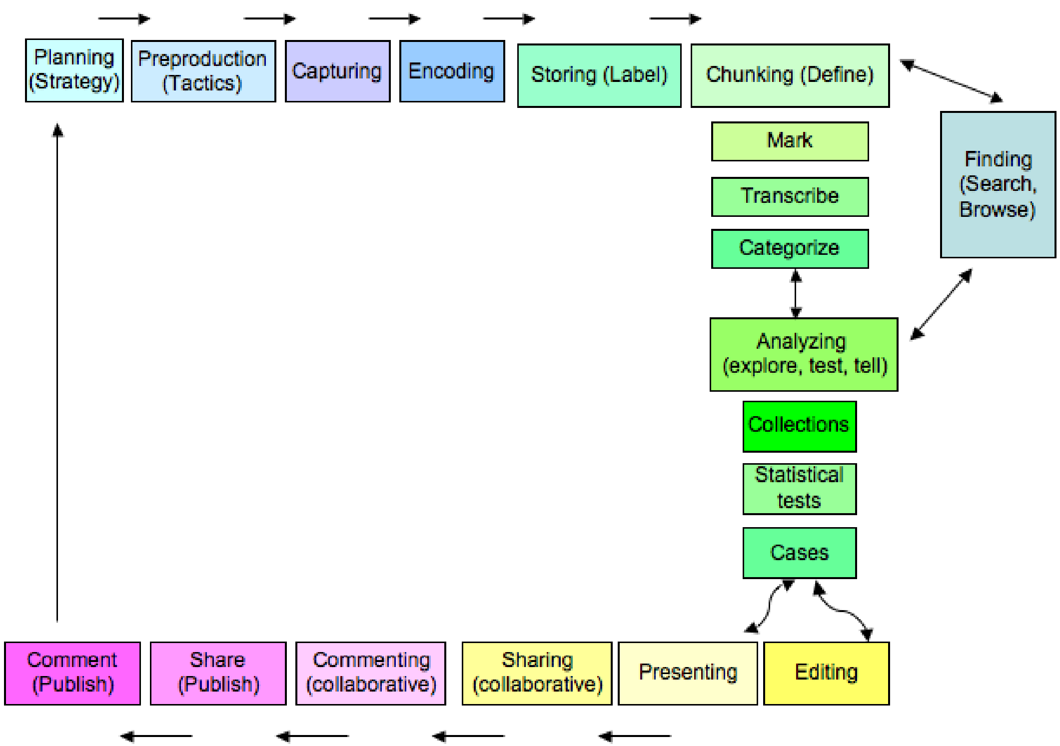
In this section, we consider the range of issues involved in the phases of video research workflow often described as *sharing* and *reporting*. It is important to observe that video research workflow is highly iterative, and not a simple linear flow from capture to transcribing to coding to reporting. The video researcher begins the process by pulling video recordings into some kind of order, from the simple act of labeling them for easy retrieval later to the much more intricate activities that add the value of interpretation to these records. The researcher may chunk the video record into segments that are defined by event boundaries, time markers, or a variety of semiotic considerations, as explained in earlier sections. And the researcher continues by marking video segments of interest, creating transcripts at different levels of detail depending on the purpose at hand, and developing and using categories that the researcher considers useful in a recursive manner. These activities involve an ongoing accumulation of research identified through processes of finding, tracking, searching and browsing, at best yielding a deepening analysis of the human activities that have been recorded. The researcher marks, transcribes, and categorizes a little; analyzes and reflects a little; searches and finds a little; and so on, in the recursive loops that define such knowledge-building activities (analogous to the writing process). In essence, there are close interdependencies between the activities of video record de-composition (e.g., segmenting, naming, coding) and re-composition (e.g., making case reports, collecting instances of commonly-categorized phenomena, making statistical comparisons of chunked episodes). Then the workflow moves on to presenting and sharing video analyses, in a variety of formats. Such sharing may be formative as one collaboratively develops and comments on a developing video analysis, or a summative account as the video analysis is published (e.g., in a journal or on the Web or a DVD) and commented on by others in the community. To close the loop, the substantive insights from specific video research workflow activities might influence the next cycles of video research workflow in the field. This basic idea is depicted in Figure 5.1 from Pea & Hoffert (2007).

To support learning among video researchers in education, the community of scholars who developed this report advocates sharing a broad range of "boundary objects"[5] that can help inform

[4] With contributions by Sharon Derry

deliberation and choices for researchers at all points in the video workflow process. These boundary objects include such issues as technical practices, tool selection, data selection, coding schemes and practices, video data banks, metadata schemes for video, theories and conceptual frameworks for guiding video research practices, institutional review board (IRB) forms and practices, and video reporting practices and genres. We should welcome diversity in these boundary objects because they will help us move toward an interdisciplinary understanding of how to build knowledge about human activities using video records. At the same time, progress as a research community will depend on gradually moving toward standardizing some of these boundary objects and promoting their widespread use.

FIGURE 5.1. DIAGRAM OF VIDEO RESEARCH WORKFLOW PROCESSES (PEA & HOFFERT, 2007)



Consider the aphorism: Words are the chains that set us free. This paradoxical concept makes more sense, Wittgenstein (1953) explains in his *Philosophical Investigations*, when considered in light of the "problem of other minds." Words "set us free" in the generative sense that each new occasion of

[5] The notion of boundary objects was developed by Star (1989), where she considers how "like the blackboard, a boundary object sits in the middle of a group of actors with divergent viewpoints" (p. 46). Bowker and Star (2000, p. 298) present evidence that boundary objects can be ideas, tools, stories, memories, and material items, and that as they circulate in networks of actors across situations, boundary objects play different roles in communication.

language use is creating a unique expression, different in at least some respects from any other occasion in terms of context, speaker history, and intent. But these words are also "chains," because there must be some commonality, a constraint in meaning, to provide the very possibility of building bridges between minds, of sharing ideas and perspectives that another mind can understand. Words need to build on some common meaning to be understood by communicators, or else a language user would be uttering terms in a private language that only she or he understands.

This introduction is meant to draw an analogy between words used for communication and the development of standard boundary objects to support scientific knowledge building and communication through video research. Standards of certain kinds will be essential for the video research community to build a cumulative scientific knowledge base. The questions to be raised are what kinds of boundary objects can be agreed to with little controversy, and what kinds are likely to keep the community mired in debate? Where are the lines to be drawn, and why?

BOUNDARY OBJECTS FOR VIDEO RESEARCH

In this section we present a short list of boundary objects that are particularly worthy of our attention and development. Each merits more lengthy treatment; citations are provided for further review. We omit discussion in this chapter of several important boundary objects that are covered in other chapters of this report, including: recording practices, data selection practices, frameworks for video analysis, and protocols for meeting institutional review board (IRB) requirements related to involvement of human subjects in research. Boundary objects for sharing and reporting of video research that are explicitly addressed here include: technological tools supporting video analysis; technological tools supporting video case development and sharing; models for sharing video in research; metadata schemas; architectures supporting collaboratories and virtual repositories; and practices addressing legal and ethnical issues related to video sharing.

Video Software Tools

Analysis tools. It is useful to briefly characterize several of the many available tools for video analysis, editing, and reflection. Accumulating findings from a workshop bringing together leading video researchers in the learning sciences and teacher education, Pea and Hay (2003) identified 10 different functions of video research that are supported (or not) by these different tools: (a) acquisition; (b) chunking; (c) transcription; (d) way-finding; (e) organization and asset management; (f) commentary; (g) coding and annotation; (h) reflection; (i) sharing and publication; and (j) presentation.

Many of the tools used by research communities have focused on developing only a few of these capabilities, and as several examples illustrate, the tools vary considerably in how well they support these functions. For example, Video-Paper Builder is designed primarily to facilitate the creation of Web-based "video-papers," educational research publications that incorporate video clips

(Beardsley, Cogan-Drew, & Olivero, 2007; Nemirovsky et al., 2001). The CLAN tools that MacWhinney and colleagues (2000) have developed for TalkBank provide an exceptional suite of transcription, coding, and annotation tools but are not oriented to supporting reflection, sharing, or commentary. In contrast, the Teachscape platform for providing video case studies of exemplary teaching supports chunking (by highlighting sections of each of the videos, for particular instructional purposes) and reflection (by supporting study groups of teachers who use the online community features at home, e.g., Lu & Rose, 2003). But the Teachscape platform does not support development of coding schemes or provide transcription tools, because it is designed more as a teacher professional development environment than as a support for research.

There is a long history to video annotation and analysis systems, which have been under development for at least two decades (e.g., Harrison & Baecker, 1992; Mackay & Beaudouin-Lafon, 1998; Roschelle, Pea, & Trigg, 1990). Development of new tools continues. Such tools help video researchers create and organize video collections, create transcripts, chunk and annotate video clips, search video banks, develop coding schemes, and create summary reports that support analysis. One of the earliest leading examples was Orion, formerly Constellations (Goldman-Segall, 1994). Orion is a Web-based program, the goal of which is to foster community by enabling researchers to add and share their research videos and related descriptors, comments, links, and transcripts. Orion also supports collaborative, distributed (coders can be separated by time and distance) coding of video selections.

The Transana tool developed at the Wisconsin Center for Education Research (2005) allows researchers to create large video collections, identify and access analytically significant portions of video data, organize video clips into meaningful categories, apply searchable analytic keywords to video clips, engage in data mining and hypothesis testing across large video collections, and share analytic markup with distant colleagues. It supports transcription and supplies a number of reporting formats. Transana is a stable open source system with a large user community that has been funded by many sources and adapted for varied uses, including serving as the basis for development of video games.

Neither Transana nor Orion can support simultaneous analysis of multiple tracks. An example of a tool with that capability is Anvil, http://www.dfki.de/~kipp/anvil/, a free Java-based video annotation tool that also supports hierarchical multi-layered annotation driven by user-defined annotation schemes. The annotation board shows color-coded elements on multiple tracks in time alignment. The tool was developed primarily for research about gestures but is used more broadly.

Several video analysis tools support researchers by allowing them to mutually reference and have conversations about specific time segments from a video corpus or about specific regions within a spatial representation of a corpus. DIVER is a software environment first created for research uses of panoramic video records (Pea et al., 2004). To move toward supporting collaborative video analysis and emerging prospects for "digital video collaboratories," Pea (2006) developed a Web-enabled DIVER that allows for distributed access and annotation of consumer digital camera video. The central work product in DIVER is called a "dive" (as in "dive into the video"). A dive consists of a set of XML metadata pointers to segments of digital video stored in a database and their affiliated text annotations. By authoring dives on streaming videos via any Web browser, a user is directing the attention of others who view the dive to see what the author sees; it is a process referred to as *guided noticing* (Pea et al., 2004). To make a dive using DIVER, a user logs in and chooses any video record that has been made available in the searchable virtual video repository (which may comprise distributed video servers). The video selected can be viewed using standard video controls. As the video plays, a user can manipulate a virtual camera viewfinder on top of the video to focus on a specific area of interest. By clicking a MARK button, the user saves a reference to a specific point in space and time within the video and places it within a data container on the DIVER Web page that is signified with an image thumbnail. Dives can also be created by creating pointers to an entire segment of the video and storing the path taken by the virtual viewfinder during that segment. Marks and longer segments can be annotated by adding text. Multiple users can replay dives simultaneously, although there is no need for users to watch the same portions at the same time.

Reed Stevens' VideoTraces system (Cherry et al., 2003; Stevens & Toro-Martell, 2003; Stevens, 2007) is oriented to reflection and presentation, by enabling users of the software to lay down a reflective "trace" on top of a video record (the "base" layer that can be played at variable speeds). The trace consists of voice and text annotation and a pointing gesture implemented as a hand cursor. A VideoTraces file may then be replayed so that one hears the audio trace overlay and can see the specific aspects of the video record that the cursor "points at" and upon which comments are being made. The fact that Stevens and colleagues have used this system in science education museums and in diverse courses in higher education, including rowing and dance composition, illustrates the value of this methodology for providing a time- and space-based interpretive layer on video records. Stevens' use of virtual pointing and voice-recorded commenting within a video record provides a complementary but different mechanism to DIVER's "guided noticing" for achieving common ground among researchers analyzing a complex video stream. For now, the VideoTraces system is a stand-alone desktop application written in Macromedia Director, but a use community can respond to a file at a VideoTraces installation site in the manner of a threaded discussion.

We are able to highlight only a few example tools in this report, although many others exist and development of new tools continues as a thriving enterprise. Moreover, standard tools for qualitative social science research, such as NUD*IST, NVivo, and ATLAS.ti., also possess some basic capabilities for supporting video analyses. Video editing and chunking are often accomplished with commercial tools such as Apple Computer's iMovie or Adobe Premiere, but these are not oriented to coding or reflection, which are among the needed functions described above.

Tools for developing and sharing video cases. There are many instances of researcher-created video cases of classroom practices, as well as teacher-created video cases that are accessed and used to share teaching scholarship with other teachers and for teacher professional development. Consideration of what constitutes a *case* is discussed further in the sections of this report on data selection (Chapter 3) and learning with video (Chapter 6). Examples of how cases are being used to support teacher learning and research on teacher learning are also described in Chapter 6.

Although video cases are sometimes published as instructional materials (e.g., Hammner & van Zee, 2006), most video cases are "shared" for instructional use rather than "reported" as research. Diverse computer-based tools exist to support both development and sharing of video cases for teacher professional development, including the commercial products Teachscape and LessonLab. LessonLab (owned by Pearson Education) provides a client-server solution for supporting K-12 schools in constructing training materials from video that they capture themselves. Related efforts include the Carnegie Knowledge Media Lab, the Case Creator Project (Doerr et al., 2003), Indiana University's Internet Teaching Forum (Barab, MaKinster, & Schecker, 2003), eSTEP (Derry et al., 2005), and the work of Schrader et al. (2003) on pre-service teachers' Web-based video cases in elementary literacy.

Elaborated documentations of professional vision in teaching have been developed at the Carnegie Foundation for the Advancement of Teaching. The Carnegie Foundation, through the Carnegie Academy for the Scholarship of Teaching and Learning (CASTL) and the foundation's Knowledge Media Laboratory, provides exemplary teachers with resources and technical support to fully document an extensive aspect of their teaching, such as a course. Their stories are partly expressed in richly annotated Web-accessible video cases http://gallery.carnegiefoundation.org/. The foundation's Knowledge Media Laboratory currently makes freely available the KEEP toolkit, an easy-to-use Web-based system at http://www.cfkeep.org/static/index.html for creating, archiving, and sharing cases of teaching scholarship.

Related efforts include the Case Creator Project, http://www.sci.sdsu.edu/mathvideo/cc/, which provides a tool that teacher educators can use to create interactive video case studies of teaching. Cases are created by importing QuickTime videos and transcripts, creating an "issues matrix" of many different pedagogical issues that are relevant to the case, and adding Web hyperlinks and/or supplementary text. Teachers and teacher educators have also used in a similar way the previously discussed VideoPaper Builder, a Web-based archival publishing environment, to create and share video cases for teacher professional development.

Formats for Sharing Video Research

The field needs cases and models for different ways in which video data are shared, commented on, and reported in concert with print and other media. Moving beyond the standard journal-reporting formats discussed in the previous chapter on video analysis (Barron & Engle, this document), we provide several exemplars of practice that include video data in the public reporting of research. Each one is regarded as a classic by many researchers, and each was produced by a senior researcher who has substantial experience with the challenges of reporting with video data.

The first example is drawn from a "multiple analysis" project: the same video data independently analyzed by several leading researchers with differing theoretical perspectives. The analyses were published in a single issue of the journal *Discourse Processes* (*27*, no.2; 1999) as separate articles, with an introduction by the researchers whose work generated the original video data and with commentaries by additional researchers, much as in a conference symposium with discussants (which had in fact taken place before the writing of the final articles). In this case the data made available to the article authors, consisting of six minutes of a single-camera video stream, was provided on a CD-ROM included with the distribution of the printed issue of the journal. The CD-ROM also included a complete transcript and a drawing of the physical setting.

The second example is the distribution, again on CD-ROM but in a limited way and primarily to interested scholarly colleagues, of parallel print and multimedia versions of two research publications by Goodwin (2000; 2003). Provided were portable data format (.pdf) versions of the printed articles and more complete versions, including links to video clips, in-line image stills, links to audio-only files, and graphical mark-ups of transcripts and stills showing relationships (e.g. with drawn arrows). The multimedia versions (developed with Marjorie Goodwin) made the relationships between data and argumentation far clearer than is possible in the printed versions, which include only textual transcriptions. This model creatively uses evocative still-frame capture from a video recording to represent vital aspects of an interaction sequence. While Margaret Mead and Gregory Bateson pioneered the use of photographic stills from film for ethnographic analyses in the 1930s and 1940s, the Goodwins' techniques illustrate many unique ideas for marking out and labeling the central properties of images used in analyses. A sense of the hypermedia style of the multimedia versions can be gained from browsing: http://www.sscnet.ucla.edu/clic/cgoodwin/projects.htm.

The third example is the availability on a Web site, http://www.pointsofviewing.com/, of brief video clips keyed to pages in the text of Goldman-Segall's *Points of Viewing Children's Thinking* (1997). At the bottom of relevant pages in the printed book are very small video stills representing the action analyzed in the text. Relevant video clips can be accessed on the Web site, and site visitors may add commentary. The commenting facility is derived from a research tool and itself exemplifies the epistemological stance of the research: the meaning of what we see depends on the perspectives (spatial and cultural) from which we view it.

In each of these cases an important criterion is met:

> *Make available to the audience of the research report a sufficient sample of the video data on which the report's argument is based, to allow the audience to assess the quality of the argument based on the data.*

Experienced researchers agree that just as the map is not the territory, so the transcript is not the video (nor the video, the event!). Even if research results depend mainly on analysis of transcripts, access to a sample of original video allows scholarly peers to assess the results of transcription and to place analyses in the wider context of features of the video-recorded event that may not have appeared relevant to the original researchers. Making available a sample of original video is a less stringent standard than making all data available for re-analysis. The purposes are to enable researchers to more clearly convey the evidentiary basis of their arguments and to permit a closer assessment of the work reported.

Given the limitations of print publication and of material distribution of media (e.g., through DVD), it seems likely that the guideline for good research practice as described above – making available a sample or original video – can best be met in the near future by use of online multimedia supplements to or versions of printed research reports. More broadly, we need to share and debate cases of research involving video analyses reported in standard journals, as well as models for alternative and experimental formats (e.g., good Web sites, such as those previously described, that incorporate video cases, analyses, and publications).

There are also vital roles to be played by early release of findings in a formative mode before traditional print archival publications are developed in a summative mode, as in the justly famous case of e-prints in fields such as high-energy physics. The analog in video research may well be draft releases of video analyses that are shared openly with a community (such as members of a collaboratory) before archival versions of these video analyses are published digitally, either in print, on-line, or in CD-ROM or DVD media. It is now possible to upload and publish digital video recordings so that they can be played in streaming media or downloadable format not only from a Web site devoted to video (e.g., Google Video or YouTube) but also using a video player that can be inserted into blogs or social networking sites. Thus the researcher can create a composite video analysis that references multiple clips that may reside on multiple servers and be provided to observers as a seamless composite re-mix of video clips (Pea, 2006). Such flexibly adaptive uses and re-uses for video data and analyses raise important issues concerning attribution, standards for re-use and re-mixing, protocols for protecting human subjects and the like, as will be discussed further in this chapter and the final chapter on ethics.

Sharing Video as Data Sources for Research

As noted above, it is good practice to make a sufficient sample of video available with published research based on that data, which enables readers to make certain kinds of judgments about the data and how it is being used. But it is also good practice to find ways to make a larger fraction, or even the complete corpus of relevant video sources, available to peer researchers for re-analysis. Reasons for doing so include making it possible to subject claims based on the data to scholarly debate and enabling other researchers to benefit from the time – and in many cases public money – invested in acquiring the data. In the past, making video data available was not practical because of the difficulty and expense of copying and distributing analog videotapes. Such drawbacks no longer apply to digital video data, and in the near future even very large video files will be made available online. In this section we consider what boundary objects must be further developed to support such sharing.

Metadata schemas. As interesting as the distinct video tools described above are, the most important lesson derived from our video research workshop was that the usefulness of such tools is limited without effective metadata schemes (Pea & Hay, 2003). Unless metadata coding and affiliated XML schemas are used for the purpose of exposing such work to browser search, analyses developed with any of these tools will be isolated in data islands that can only be used and understood within the tools and projects in which they are created. This is a serious problem.

Examples of the type of work on coding metadata that video researchers must undertake include the Gateway to Educational Materials (GEMs) instructional topics hierarchy (www.thegateway.org/), which builds on the Dublin Core (http://dublincore.org/). Another example is found in the activities of the OLAC (Open Language Archives Community, www.language-archives.org), which conforms to the larger OAI (Open Archives Initiative, www.oai.org). The stated goal of OLAC/OAI is that "any user on the Internet should be able to go to a single gateway to find all the relevant language resources available at all participating institutions, whether the resources be data, tools, or advice. The community will ensure on-going interoperation and quality by following standards for the metadata that describe resources and for processes that review them." Another important project involving coding metadata for instructional materials is the Sharable Content Object Reference Model (SCORM, http://www.adlnet.gov/scorm/index.aspx), a widely used standard and specification for Web-based e-learning objects that uses XML. These efforts are based on the emergence of the Semantic Web and its use of the Resource Description Framework (RDF), which integrates a variety of applications using XML for syntax and URIs (universal resource identifiers, which include URLs) for naming.

Although the challenges affiliated with establishing broadly applicable metadata for video analyses and video cases in learning and teaching are significant, including the need for generic and discipline-specific metadata categories, such efforts are needed to achieve the broader goals of establishing distributed research teams that can communicate about their video data productively.

Virtual repositories and collaboratories. Here we consider the prospect of sharing video through "digital video collaboratories" in which researchers who are distributed across time, location, discipline, and hardware platforms can upload video files as common resources for multiple researchers to examine. Although an individual researcher or group might have a sizeable collection of digital video assets, repositories associated with video collaboratories are envisioned on a larger scale. Further, such repositories include more than video, and for this reason, the phrase *virtual repository* is used to characterize a distributed set of heterogeneous video, metadata, client tools, and other digital resources contained in a single searchable archive. An example of such a virtual repository is Google Video, where video files and metadata associated with them are stored and accessed across many thousands of computer servers.

A virtual repository is a key element in collaborative research because it provides a research community with an accessible touchstone corpus of empirical materials and analyses (Berman, Fox, & Hey, 2003). There currently exists no such virtual repository for video data in the human sciences, although the Open Video Project has developed a large testbed resource for digital video research work on such topics as automatic segmentation, summarization, surrogate representations of video content, and face recognition algorithms (Geisler et al., 2002). The closest analog to a video repository currently is TalkBank, which provides a few heavily-used and oft-cited data corpora (particularly audio data) in a number of language-related sub-disciplines. However, TalkBank is currently a site-specific, not a distributed, repository.

While a research community might be built around a single site-specific repository, video storage requirements demand distributed storage. The storage needs are vast for even 100 researchers contributing a few hundred hours of video each (a common corpus size for a single study) at a variety of resolutions and different compression ratios. This is a "small" corpus relative to the many thousands of human scientists using video integrally in their research. A moderate-size research community would need to store and manage tens and even hundreds of terabytes (TB) of video (with petabytes and exabytes close within view). Consider that television worldwide is generating about 31 million hours of original programming (~70,000 TBs) each year, while worldwide production of original film is about 25,000 TBs per year (Lyman & Varian, 2003). Several research centers already serve data from petabyte-size storage archives (http://en.wikipedia.org/wiki/Petabyte).

An important research issue in distributed storage is insulating users and applications from idiosyncratic features of multiple repositories. This will require an intermediate software layer that can query each specific repository and translate whatever data are returned into a standard form. This software architecture would provide repository services to client applications via a public interface. The software would interact with repository-specific translation components that map generic calls for access, search, and retrieval into repository-specific interfaces. Using this client software, repositories could expose their contents to all members of the collaboratory without altering their practices for storing and retrieving video and metadata, so long as they also implement a version of the translation layer.

Developing a practical search function is perhaps the greatest challenge in establishing a virtual video repository. There is a large gap between the ideal of a single searchable repository and the reality of repositories with heterogeneous metadata schemes, some standardized and others ad hoc. We suggest that at least three different types of search capabilities will need to be developed, each having implications for metadata development and the functions of the software layer that translates between the generic virtual repository interface and the specific interfaces of each local video repository:

1. Full-text search of all metadata.
2. Core-metadata search. The repository would support a core set of metadata (e.g., Dublin Core) guaranteed to apply to all local repositories. Thus resources in all participating repositories would have a base level of visibility.
3. Extended-metadata search. The repository would expose to the user information about all of the metadata schemas available across the local repositories to which the repository has access. Users would select metadata schemas for searches. Only repositories supporting those schemas would be queried.

Different researchers' video repositories should not have to re-index data to a common metadata scheme, rather all members of a collaboratory's repository must support a core metadata set (such as the Dublin Core), while exposing the user of the virtual repository to a broader range of metadata schemes. The development of a scientific field is enhanced by the common ground established by shared metadata. An example of researchers working toward this goal is CMU's Brian MacWhinney and his group. They have been building into the TalkBank XML Schema (xml.talkbank.org) a system for classifying interactional structures – metadata characterizers based on the vocabulary of analystic methods such as conversational analysis, speech act theory, discourse analysis, and classical rhetoric. This metadata development is to be compliant with OLAC (Open Language Archives

Community, http://www.language-archives.org/) and the larger Open Archives Initiative (http://www.openarchives.org/).

Norms and Practices for Attribution and Reuse

We recommended that researchers make original video data available to other qualified researchers and users, with the provision that they agree to abide by legal and ethical guidelines governing use, reuse, and attribution. Negotiating exactly what those legal and ethical guidelines are is part of the boundary-object work that remains for the community of educational video researchers to accomplish. Our thoughts on these guidelines that follow pertain to helping this community overcome barriers to broad sharing and reuse of video. (We note that in some instances there are barriers to broad sharing due to concerns over the rights of human subjects who appear in the videos. Discussion of this human subjects issue is omitted here but covered in the chapter on ethics).

Attribution standards and policies. We need to develop sensible attribution and authorship policies for video data. Both the metadata for and analyses of video records need to indicate authorship and attribution. There are considerable subtleties here that will require learning from best practices in related fields (e.g., motion pictures, music, photography, published written works). For example, in the case of text and photos, there are now licensing schemes (see below) under which authors may choose to contribute their media for the public good, with or without attribution, for specific purposes (e.g., non-profit, commercial).

Standards governing video re-use and re-mixing for particular purposes. This issue is simultaneously exciting in its potential and vexing in its challenges. As in the case of data sharing in genomics and neuroscience, which is now widespread and even required by some journals and funding agencies, the video data used in learning and educational research could, with suitable human subjects protections, help accelerate the growth of scientific understanding of learning and teaching as multiple researchers gain access to video data records that now tend to reside on the shelves and hard disks of individual researchers. The nonprofit Creative Commons licenses have built on the "all rights reserved" concept of traditional copyright by offering different simple licenses that follow a voluntary "some rights reserved" approach (e.g., free re-use with attribution). They establish a flexible range of protections and freedoms as well as protections for such creators as authors, artists, videographers, musicians, and educators.

The rapid uptake, within many communities, of Creative Commons licenses that content creators use to freely assign rights to their texts, photos, music, and videos for enabling their re-use and, with some of the licenses, re-mixing, has illuminated frontiers for intellectual property rights related to educational research video. There are many obvious advantages to be garnered from being able to release publicly certain rights for use of educational video.

CONCLUDING COMMENT

The premise of this chapter is that those who conduct educational research based on video records are more likely to advance cumulative knowledge building if a major part of their research activity includes sharing and vetting the boundary objects that are integral to the socio-technical practices of video research. To return to Wittgenstein's aphorism for words and apply it to video research, we see standardized boundary objects as essential chains that will allow the video research community to make progress toward this goal.

6. Research on How People Learn with and from Video[6]

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In this section, we examine what and how people learn from interacting with video. Much of our discussion focuses on what and how *teachers* learn from interacting with videos of *classrooms*. Our emphasis on teachers and classrooms stems not only from this report's focus on educational research, but also from the wealth of recent video-based programs that seem to take for granted, to some extent, that video can be a valuable resource for teacher learning (Driscoll et al., 2001; Seago, Mumme, & Branca, 2004; Schifter et al., 1999). We explore below several reasons why video might have the potential to support teacher learning as well as the kinds of learning we might expect video to engender more generally.

Grounds for Fear and Optimism

Video records are complex materials, as they must be to capture even some of the complexity of classroom processes. Research has documented some of the obstacles to learning from such complicated materials. Because videotaped representations are so rich, viewers can attend to only a selection of what might be noticed, and that selection can be biased in ways that may hinder learning (Goldman-Segall, 1997; Roschelle, 2000). Viewers can very quickly form lasting impressions based on very thin slices of video, sometimes as little as 30 seconds' worth (Ambady & Rosenthal, 1993; Miller & Zhou, 2007). Americans in particular tend to focus on personality characteristics in attempting to explain behavior (Morris & Peng, 1994); such a focus may lead viewers not to notice the decision-making, content knowledge, pedagogical content knowledge, and other characteristics that underlie effective teaching. Furthermore, viewers may also take an evaluative, rather than an analytical, perspective. This tendency to evaluate may hinder their ability to consider why a videotaped lesson plays out the way it does and what they might learn from it (Hammer, 2000; Putnam & Borko, 2000; Rodgers, 2002).

Most of the problems listed above – the attentional biases that cause viewers to notice some aspects of classroom interactions and not others, the attributional stances that affect how viewers interpret what they see, and the epistemological beliefs that temper what they learn from viewing – are not unique to videotaped representations of classroom processes (Little, 1993; Spillane, 2000). In fact,

[6] The authors are grateful for contributions to this section from Hilda Borko, Catherine Lewis, Kevin Miller, Dan Schwartz, and Rand Spiro, as well as contributions and feedback from Sharon Derry.

recent research suggests that video representations may provide a means of overcoming such biases. For example, Sherin (2004) argues that because videotaped events are not live, they can be watched repeatedly, and viewers' attention can be directed to important events. Similarly, Levin (1999a) describes cases in which video is watched in the context of group discussions; in the course of such discussions, biases are identified and viewers learn new ways of thinking about classroom processes. Clearly, effective use of classroom videotapes requires the development of pedagogical approaches appropriate to these complex media, approaches that take into account the biases and prior experiences that viewers bring to the task of watching a classroom. Along these lines, several researchers have demonstrated that, in some contexts, classroom video can be a particularly effective tool for promoting the development of key aspects of teacher expertise (Santagata, Gallimore, & Stigler, 2005; van Es & Sherin, in press).

In what follows, we first discuss four issues researchers should consider when designing video-based materials. Next, we describe potential learning outcomes from such materials, both in terms of individual teacher learning and in terms of changes at the level of the group of users. We conclude by illustrating these ideas with several examples of video-based programs that are the focus of current research on teacher learning.

Issues in the Design of Video Learning Environments

One theme in the discussions that took place among the writers and conference participants within the research community that assembled this report was whether we might be able to develop process and technical standards for creating and using video cases of instruction. We highlight below four design dimensions that can have a powerful influence on the ways in which video-based materials are used and the learning that occurs as a result.

Technological infrastructure. Technological advances, particularly in the past two decades, permit the use of a variety of technological infrastructures for video-based materials (Brophy, 2004). For example, a teacher might simply watch a video of a classroom on a VCR and have the option to play, rewind, fast forward, or stop the tape. In contrast, a multimedia system allows for rapid movement from point to point in a video (e.g., Bowers, Doerr, Masingila, & McClain, 2000). With digital media, the viewer can arrange segments into sequences that differ from the order in which the video was captured (e.g., Lampert & Ball, 1998). Other programs offer the capability to annotate and edit videos, thereby permitting the user to create new video cases (DiMattia, 2002; Pea & Lemke, this volume).

Video content. A second issue concerns the content of the video, that is, what kinds of classrooms, teaching, and interactions are selected. For instance, some researchers and teacher educators recommend the use of exemplar videos that highlight "best practices." Others (e.g., Seago, 2004) argue that video is valuable precisely because of the ability to illustrate complex teaching dilemmas that then call for further analysis on the part of the viewer. Additional issues concern whether users view video that was recorded in their own or others' classrooms, whether to film whole-class activities or one-on-one situations, and whether the video depicts naturally-occurring activity or was staged. While researchers generally concur that video from real classrooms is most beneficial to teachers, many video cases are highly edited to create a useful "text" for teacher investigation (Brophy, 2004; Merseth, 1996). In addition, questions remain concerning the extent to which video cases can be used productively by persons other than the original designers (Kagan & Tippins, 1991; Lampert, 2001). Formal features of the video such as camera angle, sound quality, and shot distance also affect the content of the video by structuring what can be seen and heard (Hall, 20002; Roschelle, 2000).

Task structure. Video alone does not provide professional development for teachers (LeFevre, 2004). Instead, it is the ways in which teachers interact with video that govern the potential for learning. Specifically, how teachers understand the task to be carried out – what we refer to as *task structure* – is a key element in the design of video-based programs. For example, in some cases, teachers may be asked to look at video with an eye toward simply making sense of student thinking (Sherin & Han, 2004). Alternatively, a viewer might look at the same video while considering possible instructional moves a teacher might take (Santagata, 2005). Another possible task structure is the one imposed by the National Board for Professional Teaching Standards, which provides a highly prescriptive set of activities for teachers to complete as they prepare a portfolio for submission (Serafini, 2002).

Social structure. A final issue to consider involves social structure, that is, the ways that teachers are organized to use the video-based materials and how teachers understand their participation in this organizational scheme (Putnam & Borko, 2000). A wide variety of social structures and combinations of structures are possible: for example, teachers may work in groups and/or alone, as part of a university course, or in a voluntary capacity. The type of facilitation provided also falls under this category, as do the different kinds of roles that participants take on as a program is enacted (Levin, 1999b; van Es, 2006).

The four design dimensions discussed above are realized in a variety of ways in current programs for pre-service and in-service teachers, and several specific programs will be discussed later in this report. Before doing so, we turn to another critical issue in the design and use of video-based materials for teachers — exploring the learning that occurs as a result of engaging in such programs.

Learning Outcomes

In investigating the learning outcomes from teachers' interactions with video, we consider learning at two levels. First we turn to the learning that takes place at the system level and discuss changes in the organization – in the collection of people and artifacts that are involved in the analysis of video. We then discuss the learning that occurs for each individual participant, that is, what changes in a person's knowledge.

Changes in the video viewing system. Imagine a group of teachers who meet regularly to examine video records during the course of one school year. Analysis at the system level would look for changes in the way that the group functions from the beginning of the year to the end of the year. Changes might be observed across all four design aspects described above. For example, in terms of the technical infrastructure, teachers might start using some features of the program that they did not make use of initially. Sherin (2004), for instance, found that with time, teachers came to request multiple viewings of classroom video excerpts in order to "better see what was happening."

Changes may also take place in terms of the video content that is viewed. This could occur simply because a group of teachers selects different kinds of video clips for viewing. More dramatically, if a group of teachers is looking at videos of the group's own practice, and the teaching practice changes, then the video the teachers are viewing would also change. This sort of change is particularly likely if the video-based learning is tied to a program in which teachers are being taught to adopt a specific set of instructional practices. This was the case in a program developed by Borko et al. (in press), described in more detail later in this report. In brief, as teachers reacted to videos of their classrooms and worked to implement instruction that engaged students in inquiry activities and discussion, a qualitative shift occurred in the types of videos that the group subsequently viewed.

The ways in which teachers view the task and their ability to engage and succeed with the given task may also change over time. Consider Brantlinger and Sherin's (2006) study of a group of high school teachers who met together weekly as they prepared portfolios for submission to the National Board for Professional Teaching Standards. As the teachers discussed the National Board standards in the context of viewing video of their classrooms, they came to be more articulate about the standards, focusing more on those features of instruction to which the standards referred.

Finally, changes may also occur in the social system of a video-based professional development program. Participants' roles may change over time, and the group may develop new norms for viewing and discussing video together. For example, van Es (2006) found in one case that initially only the facilitator raised substantive issues related to the video for the group to discuss, but over time, all participants took on this role. Similarly, the role of critic shifted among members as participants increased their tendency to base alternative explanations on specific evidence in the video.

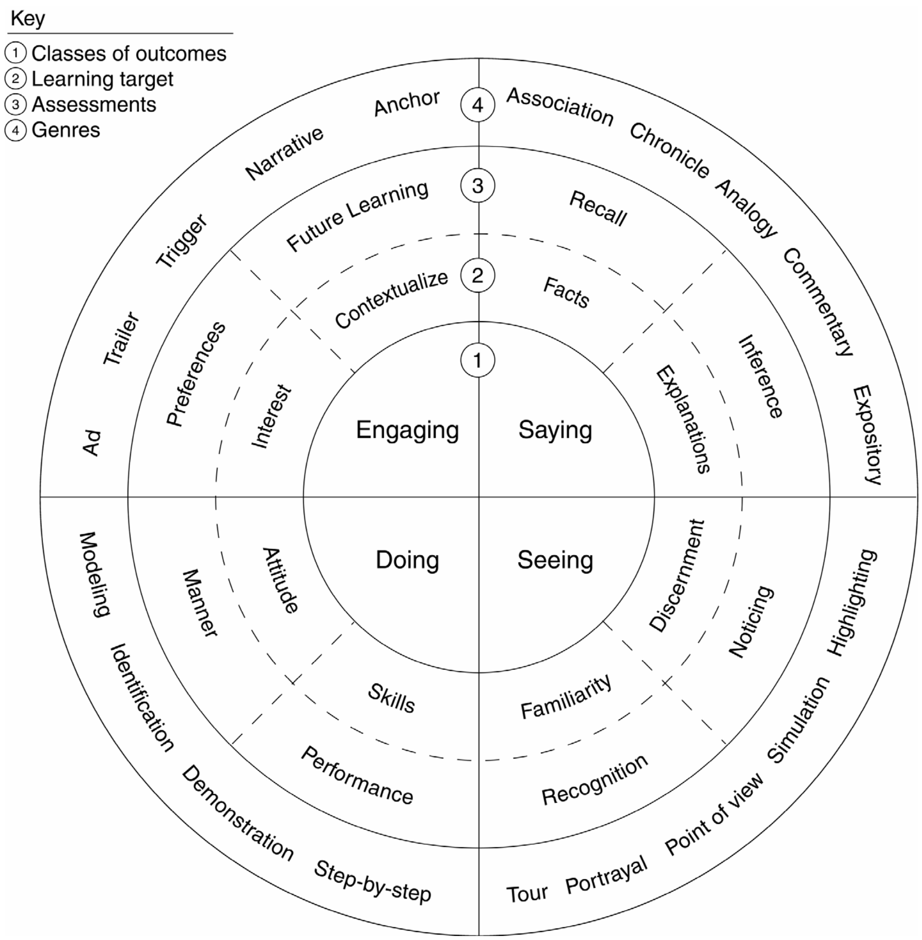
Changes in the knowledge of individual. As individuals interact around the viewing of video, what types of learning might we expect to occur? Here we consider specifically the categories of learning that are afforded by "designed video" – video that has been edited or produced with the goal of achieving a particular learning outcome, perhaps to test *a priori* hypotheses (Schwartz & Hartman, 2007). Consider the four main learning outcomes outlined by Schwartz and Hartman (2007): (a) doing, (b) engaging, (c) seeing, and (d) saying. The center of Figure 6.1 organizes these four classes of learning outcomes, while ring number 2 indicates more subtle breakdowns of the learning targets.

(a) doing. Video is an ideal medium for illustrating classroom activities and interactions. Thus, it seems well-suited to helping teachers learn to act in certain ways. For example, one might use video to model an instructional practice in detail or provide step-by-step instructions for carrying out certain tasks of teaching. More specifically, a program might use video to demonstrate how to use a particular manipulative for teaching mathematics or to model different methods for teaching students about fractions. Such programs are designed to support the learning of "doing," that is, to provide teachers with new skills or techniques for teaching particular topics.

(b) engaging. A second potential learning outcome involves "engaging" learners. In this case, video is used to increase teachers' interest in a topic and more importantly, their motivation to learn more about the topic. For example, showing teachers video of elementary students involved in a substantive discussion about scientific inquiry might prompt the teachers to want to investigate how to establish a discourse community in their own classrooms. Similarly, providing teachers with evidence of deep student thinking in urban contexts may help to influence teachers' existing attitudes about teaching and learning.

(c) seeing. Increased attention has been paid recently to the importance of teachers being able to notice and interpret significant aspects of instruction. This ability to "see" what is happening in the midst of instruction is thought to be a key component of expertise of teachers (Berliner, 1994). Moreover, video is considered by some to be *the* central media for supporting such learning (Jacobs et al., in progress; Sherin, 2007). Using video, teachers can be trained to pay attention to particular aspects of instruction and to recognize certain kinds of events as meaningful. This learning has been found to influence what and how teachers notice *during* teaching as well (Sherin & van Es, 2006).

FIGURE 6.1. A SPATIAL REPRESENTATION EQUATING FORMS OF LEARNING AND ASSESSMENT WITH GENRES OF "DESIGNED" VIDEO (SCHWARTZ & HARTMAN, 2007)



(d) saying. A fourth learning outcome can be described as "saying." The goals here are to help teachers acquire new facts and explanations and to increase their ability to recall and converse with such. For instance, programs may be designed to provide teachers with information concerning new discoveries in science or to introduce teachers to new policy documents. While the other learning outcomes described above rely on the unique strengths of visual media, "saying" can, in fact, be achieved through a variety of means. Nevertheless, other formats such as commentaries and historical chronicles have been shown to benefit from the integration of video (Rowley & Hart, 1993). It is likely that learning along this dimension is more dependent on attributes of the task and the social structures in which use of the video is embedded. For example, if teachers are asked to engage in a particular kind of evidence-based analysis of video segments, then their ability to produce those kinds of analysis in the future might improve.

TOWARD A RESEARCH PROGRAM ON VIDEO-BASED PROGRAMS

In the above discussions, we essentially adopted the viewpoint of teachers of teachers. We asked how the nature of video-based programs might differ and the dimensions along which learning outcomes might vary. But, for a moment, we want to explicitly adopt the viewpoint of researchers, albeit researchers interested in helping teachers. Stated simply, the analyses presented in the preceding two sections provide an outline of one framework on which a research program might be based: the "issues in design" we identified provide dimensions that can be varied, and the "learning outcomes" provide the outcomes we could seek to measure.

Of course, research might take on many different forms within this framework. For example, research might involve molar comparisons of different genres of video. Or, more typically, researchers might make specific systematic variations in program design that reflect specific hypotheses about the relationship between program design and learning, conducting studies that test theoretical predictions as well as examine practical questions. For instance, a researcher might manipulate whether "expert commentary" comes before or after a portrayal of some particular type of classroom instruction. Or a researcher might compare whether teachers learn more from a video presentation before or after they have tried to create their own lesson on the selected topic. In one study, van Es and Sherin (2006) explored the influence of two related video-based professional development programs on the ways that teachers learned to interpret mathematics instruction. Though similar in many aspects, the programs differed in the types of video clips viewed and the kind of facilitation provided. Multimedia applications can be well-suited to this type of comparative research because the video elements of the presentation can be held constant while the structure of the activity or the form of presentation can be manipulated as required by the research questions.

Pea and Lemke (this volume) discuss the value of negotiating common boundary objects to help the video research field accumulate a knowledge base. Research in our field might be enhanced by creating a standardized set of video materials to support research and assessment across projects. Communication researchers, for example, have created a standard set of images (collected to sample two agreed-upon dimensions – positive/negative versus arousing/not arousing) that can be used to test widely different theories but also permit cross-referencing of findings. In the area of designed videos, a common set of videos for learning research might be quite valuable. For example, a set of video cases depicting teaching and learning in science classrooms (e.g., Hammer & van Zee, 2006) could help researchers and teachers create common learning content and common assessments. These videos might serve as only one component of researchers' larger studies, but they would provide important touchstones that would permit comparisons across studies and promote accumulation of scientific knowledge.

Video Assessment

Designed video can also serve as a resource for assessing learning, either as part of a research study or as a core part of an instructional program. Ring 3 of Figure 1 indicates specific types of outcomes that one can assess with video. Hackbarth, Derry, and Wilsman (2006) used video to investigate the impact of a professional development program on teachers' ability to notice evidence and draw conclusions about adolescents' algebraic thinking through observing their problem solving. Before and after the program, teachers saw video cases depicting students' problem solving and produced written analyses of the students' work. Statistical analyses based on scoring indicated that teachers' noticing and reasoning changed during the professional development program.

Alternatively, one might use a video to describe a problem situation and assess learners to determine whether a program has helped people learn in ways that allow them to solve this problem. For example, Derry et al. (2005) presented pre-service teachers with videos of problematic classroom instruction. A student who experienced the classroom instruction was shown being interviewed both before and after the depicted instructional unit. The teacher-learners wrote analyses that were scored to determine their ability to identify problems with the learning and instruction. One of the advantages of using videos to assess learning in this way is that they can include much more information than paper-and-pencil word problems and can be offered in a way that does not depend on the reading abilities of students.

Paradigms for Video-Based Professional Development

Before concluding, we want to also consider some paradigms that researchers employ to study the effects of video-based instruction on learning. To begin to do so, here we provide five examples of designed environments for teacher learning in the context of video-based professional development. We consider each of these approaches as "standard" in that they represent research-based models that other researchers could employ and develop in their work.

Video Clubs. Ever since its introduction to teacher education, video has been used to record field observations. Initially such recordings were used mainly as a substitute for a live classroom observation by a supervisor (Olivero, 1965). In the mid-1990s, however, such recordings began to be used by researchers and teacher educators in the context of video clubs: meetings in which a group of colleagues watch and discuss video excerpts from each others' classrooms (Thomas et al., 1998; Tochon, 1999; Sherin, 2004). In a typical arrangement, a facilitator videotapes classrooms and, with input from the teachers, selects a short excerpt of video to show at the next group meeting. In the video club, the teachers view the video excerpt and discuss what appears salient to them in the video.

Video clubs have been shown to support teachers, particularly in learning to notice key features of classroom events (Sherin, 2001; van Es & Sherin, in press). For example, Sherin and her colleagues at Northwestern University designed a series of video clubs to help teachers learn to pay close attention to student mathematical thinking. Their analysis revealed that within the meetings, teachers' conversations shifted from an initial focus on issues of pedagogy and classroom climate toward an emphasis on student thinking. In addition to paying more attention to students' mathematical ideas, the teachers also developed new strategies for interpreting these ideas, including attending to the details of student statements and making connections among the ideas raised by several students (Sherin & Han, 2004). Recent work also provides evidence that participants apply these new strategies not only in the video club context but also in their teaching, as they characterize student ideas as objects of inquiry to be closely examined in the midst of instruction (Sherin & van Es, 2006).

Problem solving cycle. Borko and colleagues at the University of Colorado have developed an approach to teacher professional development referred to as the problem-solving cycle (PSC). The PSC consists of a series of three coordinated workshops organized around a single mathematics problem. Program components are designed to help teachers enhance their knowledge of mathematics for teaching and develop new instructional practices. During the first workshop in the cycle, teachers solve a mathematics problem and develop a plan for teaching it to their own students. Video clips from these lessons are then used in the second workshop as tools for the teachers to examine one another's instructional strategies and in the third workshop as a resource for exploring the students' mathematical thinking. Teachers may participate in multiple workshop cycles over the course of a school year.

Analyses of workshops indicate that over the course of two years of participating in the PSC, the full-group conversations around video became more "productive." That is, the teachers talked in a more focused, in-depth, and analytic manner about specific issues related to teaching and learning the selected mathematical problems (Borko et al., in press). Possible reasons for these changes include the development of a stronger professional community, the establishment of discourse norms, an expanding ability and willingness to learn by analyzing and sharing ideas about classroom video, and increasingly focused and challenging facilitation. Ongoing research is investigating the impact of the PSC on teachers' instructional practice. This work focuses initially on a single teacher, Ken, in order to represent an "image of the possible" (Shulman, 1986) and serves as an existence proof that the PSC approach can help teachers change their instructional practices. Analysis of Ken's videotaped lessons also documents the specific nature of changes in his teaching, including a series of incremental shifts in his questioning strategies and discourse patterns (Koellner et al., in press).

Lesson study. Lesson study is a form of professional development that has been practiced in Japan for many decades and has been recently introduced to other countries (Lewis, Perry, & Murata, 2006). Lesson study is a collaborative, teacher-led instructional improvement cycle in which teachers:

- Consider their goals for student learning and long-term development;
- Collaboratively plan a "research lesson" that will foster student learning and development;
- Conduct the lesson (which generally is videotaped), with one team member teaching and others gathering data on student learning and development; and
- Share and discuss the data gathered during the lesson, drawing out implications for lesson and unit design, and for teaching and learning more broadly.

Optionally, the research lesson may be revised and retaught to another class.

In Japan, video is typically used as a supplement to live classroom observation, for two major purposes: (a) to provide a record that can be consulted (for example, if a question arises during the discussion of the lesson or when writing a report on what was learned from the lesson study cycle); and (b) to extend access to the research lesson to faculty who could not attend the live lesson (Lewis, 2002; Sato & Sato, 2001). In the United States, some lesson study-inspired innovations rely on video without live observation of lessons (Ermeling, 2005), and video has been one of the primary means of spreading lesson study in the United States (Mills College Lesson Study Group, 2000, 2005) and of providing instructional models (Mills College Lesson Study Group, 2003a, 2003b.)

Evidence from U.S. lesson study cases indicates that lesson study can build teachers' mathematical knowledge, their ability to focus on student thinking, their use of effective instructional strategies, and their use of expert resources (Ermeling, 2005; Lewis, Perry, & Murata, 2006; Perry & Lewis, 2006). Students at a school where mathematics lesson study was practiced school-wide, for example, showed significantly greater increases on mathematics achievement test scores over four years than did students in other district schools (Lewis, Perry, Hurd, & O'Connell, 2006). However, only in Ermeling's (2005) study of instructional practices of high school science teachers was video (rather than live observation) the primary mode of lesson study.

Problem-based learning (PBL) models. Derry and Hmelo-Silver (e.g., Derry et al., 2005, 2006) used video cases in conjunction with problem-based learning (PBL) to develop pre-service teachers' abilities to use learning-science concepts to design lessons and justify designs. Small groups of pre-service teachers collaboratively viewed and analyzed video cases of classroom teaching and learning that were made available through an online repository. Groups were then presented with a problem that required them to redesign the videotaped lesson or design a similar type of lesson on a different topic. The activity adhered to a PBL protocol in which pre-service teachers first developed learning issues to explore before completing their projects. The protocol included having groups organize their work and discourse around an online whiteboard that was designed to scaffold a backward design (Wiggins & McTighe, 1995) approach by requiring students to first decide on lesson objectives, then assessments, then activities. These studies repeatedly and consistently demonstrated that the PBL approach produced performance on transfer assessments superior to that produced by traditionally-taught versions of the same courses. Whether and how the video cases themselves contributed to this performance improvement remains a question for future research.

Video case applications of cognitive flexibility theory. Video cases have also been designed based on cognitive flexibility theory (CFT). CFT is a theory of learning in complex domains that is used to aid researchers in designing computer learning environments that enable learners to move away from a mentality of retrieving "prescriptions" for how to think and act from memory. Instead, learners are prepared to freshly *assemble* knowledge and experience acquired at different times to suit the needs of whatever situation they are currently facing (e.g., Spiro, Coulson, Feltovich, & Anderson, 1988; Spiro, Feltovich, & Coulson, 1996; Spiro & Jehng, 1990). CFT-based systems have been shown to produce statistically significant increases in flexible knowledge transfer in tightly controlled experiments with random assignment of subjects to conditions (Jacobson & Spiro, 1995).

Recent applications of CFT have stressed the use of video cases. In particular, CFT-based video case environments are designed to promote the following goals: (a) the opening and deepening of viewers' perception of classroom scenes (in part by the use of video effects to direct attention to parts of scenes that often go unnoticed); (b) the fostering of habits of mind that expect classroom scenes to have multiple, interconnected elements and non-routine aspects that require multiple conceptual perspectives for understanding; (c) the acceleration of teachers' acquisition of experience (through an innovative system of incremental sequencing of video case presentations that permit more complexity to be introduced earlier in instruction without cognitively overwhelming the teachers); and (d) the development of the ability to compose an assemblage of parts of video cases to form a "schema of the moment" to support understanding and decision-making in newly encountered cases.

One recent video-case-based application of CFT has been an environment for teaching teachers two prominent reading comprehension strategies using large amounts of actual classroom video (Palincsar et al., 2007). This system was used in a controlled experiment involving experienced teachers in two week-long professional development institutes. The teachers in the CFT condition developed many characteristics of expertise in the very short amounts of time (less than 10 hours) in which they used the system. For example, they were able to demonstrate understanding of many subtleties and nuances in the use of the important but nondeterministic concept of "scaffolding" as it applied in different ways to different instructional situations drawn from the system's video corpus.

CONCLUDING COMMENTS

In this section, we discussed recent research on how people learn with and from video, focusing specifically on the role of video in teacher learning. We introduced four key dimensions of video-based programs that can influence both how video is used and the learning outcomes that result from this use. In addition, we considered learning at two related levels – what and how individuals learn as they interact with video over time; and the learning that occurs at the system level, that is, changes in how a group of viewers use and learn from video over time.

We conclude with the observation that it might be useful to think about learning at a third and higher level: the larger socio-cultural system that includes not only the teachers who learn with video but also educational researchers, teacher educators, and the evolving video technologies. In this section, we provided a summary of research on how people learn with and from video. But this is an area that is in constant flux. The tools are changing rapidly, and we are developing new ways of making use of those tools. At the same time, as teachers learn through interacting with video, they may start to productively engage with video in new ways – which we believe will contribute to the development of further innovations in the use of video-based materials for teacher learning.

7. Ethical Concerns in Video Data Collection

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General Issues Regarding Use of Human Subjects in Video Research

Acknowledging that the problem of insuring ethical, humane, dignified treatment for human participants in research cannot be fully summarized in a paragraph, we briefly characterize such treatment as requiring that participants be fully informed about the purposes, risks and potential reward of the research; that given this information they participate voluntarily; that they be allowed to comfortably withdraw their participation during a study without penalty; and that the participant's expectations and rights to privacy and confidentiality will be honored. Further, if the participant is a minor child or a member of a vulnerable population (e.g., cognitively disabled individuals), ethical treatment requires that these individuals be assisted in their decision to participate by a cognizant and responsible third party, such as a parent or legal guardian, whose major concern is the participant's welfare.

The main federal regulation that defines ethical treatment for human subjects in research is "The Common Rule" set forth in 45 CFR 46, http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm, which applies to research funded by eighteen U.S. federal agencies that have adopted the same regulations. Some granting agencies impose additional requirements, especially related to vulnerable populations such as children, prisoners, and disabled persons. Universities, which provide assurances that all research grants funded by these agencies but administered by the universities will be in compliance with 45 CFR 46, create institutional review boards (IRBs) for evaluating proposed studies to insure that the university's research programs treat participants ethically and are in compliance with federal regulations.

For various reasons, institutions, including researchers' places of employment as well as the school districts or other organizations in which they conduct research, may impose additional requirements that place even greater constraints on researchers' interaction with human subjects than might be required by federal regulation alone. These organizations often require adherence to their policies even for research proposals that are not federally funded. For example, doctoral dissertations typically must follow the degree-granting institutions' regulations regarding ethical treatment for research participants, while classroom researchers must adhere to regulations imposed by school districts. Hence researchers often must present their research proposals for approval to multiple IRBs: minimally, one associated with the researcher's place of employment, and one associated with the organization in which the research is conducted. When researchers collect data in multiple organizations, cross national or international lines, and especially if the research involves vulnerable populations, the regulatory procedures involving protection of human subjects can become complex and daunting.

In addition to guidelines and rules imposed by federal agencies and institutional policies, researchers are bound by codes of ethics associated with the professional societies to which they belong, such as the American Educational Research Association, the American Psychological Association, and the American Anthropological Association. Before embarking on a research program, researchers should become familiar with all of these overlapping but non-identical codes for ethical treatment of human subjects: those associated with 45 CFR 46; the rules and procedures of the institution in which the researcher works; the rules and procedures of the organizations in which the research will be conducted; and the rules for ethical research set forth by the researcher's professional societies. While this may seem like a daunting amount of regulation to wade through, there are good reasons to recommend familiarity with all of these ethical codes. One reason is that the topic of ethical treatment and the related regulations and human concerns about this topic are complex and subject to interpretation and disagreement. Different IRBs, even boards within the same institutions that change membership over time, interpret required regulations differently in ways that impose different restrictions at different times on different researchers. Hence, disagreements between researchers and IRB's regarding the treatment of human subjects are common. Knowledge of ethical codes and regulations helps researchers prepare well-justified proposals that explain their procedures and educate IRBs regarding what is and is not acceptable within their particular sphere of research. When disagreements arise, such knowledge can be a powerful ally in making an argument with an IRB. Program officers from funding agencies can also be powerful allies in helping researchers obtain IRB approvals for valid research procedures that meet federal requirements.

One common source of disputes is the time required for an IRB review. 45 CFR 46 and most institutions' review procedures allow for different levels of review depending on the degree of risk or inconvenience that a study imposes upon participants. Many educational research studies should qualify for exempt status or cursory review rather than the more elaborate full IRB reviews that can delay studies, because they either study classrooms as natural contexts without intervention, or because they impose experimental interventions and assessments that only minimally modify the standard educational practices in which students and teachers already participate.

Another area of potential disagreement between researchers and IRBs pertains to methods for obtaining informed consent from subjects and levels of consent required. For example, if assessment or interview data can be easily codified to protect participant anonymity, and if the researcher is able to promise confidentiality based on limited access to the data that are collected, such studies present little confidentiality or privacy risk for participants and, from the perspectives of the researcher and often the funding agencies involved, should not require elaborate informed consent procedures with signatures from both students and parents.

However, especially when minor children or vulnerable populations are subjects in research, IRBs may be cautious and impose review processes and procedures that researchers deem unreasonable. This is particularly true when video is involved. The mere addition of video collection may even require in some institutions that the research proposal receive a "full review" from the IRB. Studies using video may be treated much like medical and psychological investigations for interventions where privacy is a paramount concern. When researchers collect recordings in which individual subjects might be recognized by viewers, special concerns arise related to subject privacy and confidentiality. Participants who are recorded cannot be assured of anonymity unless their identities are technically filtered or masked, but both filtering and masking are expensive processes that could compromise the dataset for many research purposes. However, although video data is inherently non-anonymous, confidentiality can be protected in many ways, such as restricting access to the video and to personal information such as the names of the participants or the schools in which data were collected. In some situations participants may assume their video will be viewed only by individuals who do not personally know them. In such situations it may be possible to require researchers who are personally acquainted with videotaped subjects to recuse themselves from working with the video. IRBs usually expect video researchers to implement procedures that protect the confidentiality if not the anonymity of research subjects who are recorded.

Because the non-anonymous nature of video seems to make it potentially risky (e.g., it can be used in a way that might embarrass subjects), IRBs may develop special regulations and rules that are apply only to video research. For example, although the School of Education at the University of Wisconsin-Madison identifies video educational research as being eligible for expedited review, their Web site indicates that they require researchers to adhere to the following rules of informed consent:

> *It is the policy of UW-Madison's IRBs that if the research involves the use of image or audio recording of participants, the consent form should clearly state that fact. In addition, there should be a statement about how the recordings will be used and how long they will be kept. This statement should include who will see or hear the recording and where it will be used (e.g., in a classroom, professional meeting). If the investigator wants permission for the recording to be viewed or heard by anyone other than the research staff, or if it involves sensitive material, participants should also be given an opportunity to view (or listen to) the recording after it is completed. Permission for the tape to be used should then be obtained.*

As will become clear, this potentially restrictive rule could limit broad sharing of video sources of data among researchers.

Issues Regarding Broad Sharing of Video Data Sources

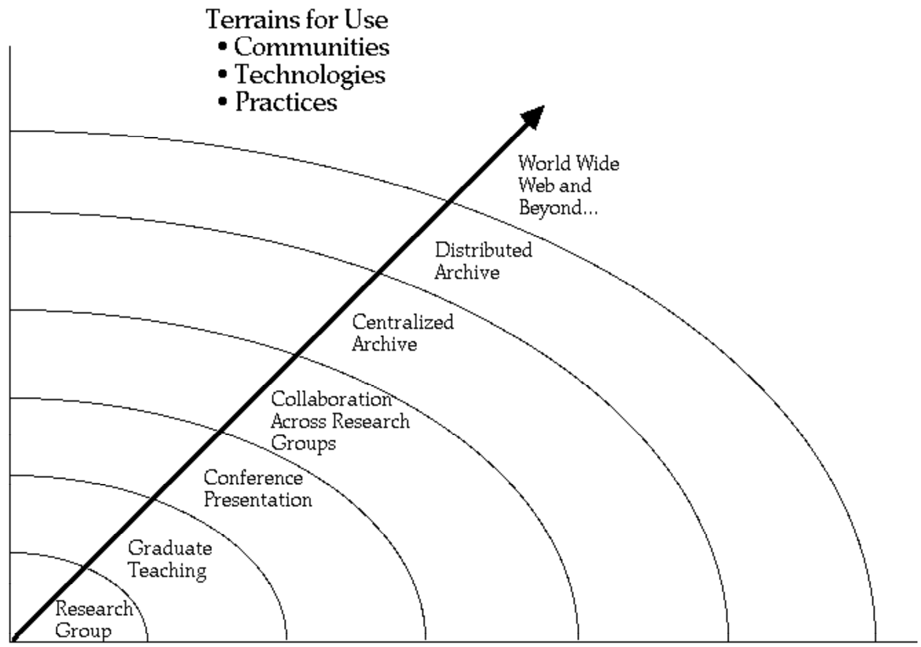
As institutions, their IRBs, researchers, and federal agencies struggle to adequately address privacy and confidentiality issues related to video and the rights of participants in video research, it is important to acknowledge the nature of the dynamically changing social context in which this discourse is taking place. One aspect of this social context is that video recording is becoming ubiquitous in life, and social acceptance of its widespread use for many purposes may be increasing. For example, video is now openly used for surveillance on many city streets and, as illustrated in such Web phenomena as Google Video and YouTube, even highly personal consumer videos are shared socially on the Internet with few privacy and confidentiality concerns being evident. A second aspect of this context is that there is an increased emphasis by research communities and federal agencies on the need for broad sharing of data sources within and across research communities. For example, the National Institutes of Health now requires data sharing by the researchers it funds, although video data sources are currently exempt from that requirement.

The use of *data corpora*, i.e., large, amassed data collections, is common in the human sciences (see Pea & Lemke, this volume). A single data corpus may be used over time by multiple research groups to address many different kinds of research questions. The creation of digital libraries for research that include video of human interaction is currently on the rise, as exemplified by the TIMSS video database (http://nces.ed.gov/timss/), used to study instructional practices, and the CHILDES (part of Talkbank) collection (http://childes.psy.cmu.edu/), used to study linguistic development in children. In past years, the costs associated with collecting video and the cumbersome nature of storing videotape kept both the amount and the distribution of video images in educational research quite low. With increasing numbers of educational researchers collecting increasingly large volumes of video data that can now be shared with increasing technical ease, it becomes important to address the ethical issues associated with such sharing.

Many video research projects are supported with public funds. Hall (2000) argues that data collected on those projects should be considered a public resource. "This is true both in the traditional sense of academics making their data available to one another for peer review and purposes of replication, but also in the sense that resources produced with public funds should be available to the public that underwrites them." Yet what parts of a video corpus should be a public resource and for what purposes are controversial issues.

A major difficulty is that video data, once collected, might be used in multiple ways and it may not be possible, at the time that a recording is made, to specify precisely what these uses might be. Further, often it is not known at the time of collection even *who* will be studying the data, because data corpora are often shared within a research community. As video records travel further from the research project in which they were collected, the types of users and uses of the video may expand in unpredictable ways. New users may have less and less knowledge about the conditions under which the video was originally collected, which creates substantial potential for inappropriate selection, use, and interpretation (Goldman et al., this volume; Hall, 2000; Miller, 2007). This problem is illustrated in Figure 7.1, below (from Hall, 2000). It is therefore a matter of ethical concern to include within the corpus (not strip from it) adequate documentation about the video, including information about research subjects, so that future users of the video will be adequately informed about the nature of the video they are analyzing and how it was collected.

FIGURE 7.1. A DIAGRAM SHOWING THAT CONTEXTS OF USE FOR VIDEO RECORDS ARE INCREASINGLY DISTANT FROM THE RESEARCH PROJECT THAT PRODUCES THEM, MAKING USES LESS PREDICTABLE.



IRB responses to a researcher's request to maintain a fully documented video corpus and to give wide future access to this corpus through the Internet will vary widely from one institution to another and even across time in a single institution as IRB membership changes. In some cases researchers might encounter IRB members whose scientific training orients them very directly to the empirical testing of specific hypotheses. Hence negotiating protocols and the conditions of informed consent that permit *emergent* and *future* analyses of video corpora is difficult and may require substantial time and argument by the original researchers. In some cases, IRBs may request that the corpus be made anonymous or that confidential information be removed from it, or that it be allowed to exist for only a limited period of time and then be destroyed. In some instances, studies that could be conducted by graduate students or junior researchers who were not involved in the original data collections could be threatened because of issues of informed consent and privacy raised by IRBs. In most cases, researchers should expect that board members will require substantial education as to the nature and value of collaborative video-based educational research and the researchers' desire to collect data that can be kept in perpetuity and uploaded to shared video repositories.

Protocols and Informed Consent

Two-stage model. One way of protecting the rights of human subjects while making it possible to build and use shared repositories of video and other digital resources is to employ a two-stage model involving two different types of protocols—*collection* protocols and *use* protocols.

A collection protocol is used to build a collection or data corpus. The collection protocol specifies how data will be collected, who will do the collecting, and what the constraints on ultimate use will be. The collection protocol must be reviewed and approved by the local institutional review board (IRB). The collection protocol must be renewed and kept active for the full period of data collection and initial intended use. However, the corpus itself may continue to exist after the collection protocol has been terminated. A collection protocol will almost always include preparation and use of one or more informed consent forms (ICFs).

Use protocols are always dependent on a previously approved collection protocol. Use protocols have no associated ICFs but are bound by the terms of the ICF(s) of their parent protocol. Like collection protocols, use protocols must be reviewed and approved by the IRB of the institution that owns and maintains the data corpus. An approved use protocol must be in place for the full period during which some responsible party has access to some or all data residing in the corpus for the purposes of carrying out some form of approved research. The use protocol should include the original ICF and specify what data will be accessed, who will have access, how access will be implemented and controlled, plans for publication, and possibly plans for data destruction when the study is completed.

Informed Consent Forms. It is essential that the ICF be worded to ensure that the persons being recorded can easily understand the purpose of the research, the potential benefits and risks of participating, and that the recording process can be stopped or that they can conveniently withdraw from a study without penalty or prejudice. Similarly, it is necessary to word the ICF so that the researcher's interests are also protected. For example, the ICF might state that if a fee is promised for completing a study, the fee might not be paid in full if the subject withdraws. The ICF is, essentially, a contract between a subject and a researcher that attempts to fully inform the subject about the value and purpose of the study and the use of the data, as well as protect the interests of both researcher and subject.

ICFs must always fully inform participants but can describe either restrictive or permissive uses of the video. The most permissive type of ICF may ask that the subject (or the responsible parent or guardian) consent to unrestricted use of the video, including Internet use, with no financial consideration due to those recorded and no *guarantees* that the video will be utilized for the research purposes intended even though the researcher will make reasonable efforts to ensure appropriate use and distribution. The virtue of a permissive ICF is that it allows unrestricted sharing for appropriate research purposes and can typically be written in brief language. The disadvantages of a permissive ICF are that the wording may be questioned by an IRB, and participants, especially parents or guardians of minor children, may be especially reluctant to sign the forms. This could seriously reduce research participation.

A highly restrictive ICF may, for example, promise the following: very limited access, with users to include only the researcher's staff; full anonymity of videotaped subjects beyond the immediate context of the research by masking of faces and voices for any public showing or even for data sharing; permission to review and approve video releases in advance; specific dates for destruction of data; and specific ways in which the video will be protected from access by unauthorized persons, such as by the use of high-security networks and password-protected sites. The advantage of a highly restrictive ICF is that IRBs may approve the study more readily and research subjects may feel more comfortable and be more willing to participate, knowing their privacy and interests are protected. The significant disadvantages are the huge increases in time and expense for carrying out the conditions of the agreement, as well as an inability to archive and share the video for research beyond persons directed involved in the data collection. Highly restrictive ICFs are also typically very long, which may restrict participation in some contexts. For example, Palmquist and Crowley (2007) found in their research on families who visit museums that participants were likely to decline participation if they were first required to read detailed forms.

In reality, most ICFs represent a compromise between the most restrictive and most unrestrictive cases. A rule of thumb that supports sharing is to create the least restrictive ICF possible to encourage broad and appropriate uses of video. The ICF should provide sufficient information, comfort, and protections for subjects to help encourage their participation. In Appendix B we include several samples of moderately restrictive ICFs that have been approved by an IRB in the past. Further examples and an excellent set of guidelines for developing ICFs that allow restricted use within an online video research community can be found under the section titled "The ground rules" at the Talkbank site http://talkbank.org/.

CONCLUDING COMMENT

Our hope is that these guidelines will enable educational researchers to educate and influence IRBs and to develop protocols and ICFs that enable wide sharing and future use of video data collected for educational research. We believe that many people who consent to be recorded on video for research purposes are hoping to benefit the wider community by doing so, and that this potential benefit is increased when the video data is made available to other qualified researchers, provided those researchers agree to abide by the conditions of use approved by the original IRB.

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APPENDICES

APPENDIX A. 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 segmenting 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?

ASPECT OF TRANSCRIPT	COMMON OPTIONS	CONSIDERATIONS
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?
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 2002; 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 just 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

APPENDIX B. EXAMPLES OF INFORMED CONSENT FORMS

The items in this appendix are offered for illustrative purposes only and may serve as an aid to researchers who may adapt them for their purposes and institutional contexts. These have no official or legal standing.

Item 1:
Consent Form for Minor Children
Understanding and Cultivating the Transition from Arithmetic to Algebraic Reasoning

In signing this document I understand and agree that:

My child may participate in a yearlong scientific study designed to improve mathematics instruction being conducted by Dr. Sharon Derry in collaboration with my child's teacher.

My child's interactions in classes and in on-line computer discussions may be observed and captured by video and audio recording devices.

My child may be asked to complete assessment tasks and questionnaires designed to measure learning and belief change and that my child may be interviewed.

Most of these tasks will be scheduled as part of normal classroom activities and will be designed to improve instruction, so my child is not expected to miss any regular classroom instruction because of participation.

If my child is interviewed, such interviews will not require more than one hour of my child's time and will be scheduled with my child's consent during recess or other off-instructional times.

Data resulting from this study will be analyzed by social scientists and my child's teacher to help them evaluate and improve the instruction in my child's class.

Standardized test scores from my child's permanent school records may be accessed and used in these analyses.

Video recordings of my child's class and possibly containing images of my child may be distributed to educational groups and made available to educators on the World Wide Web, for the purpose of training teachers and other educational specialists.

I authorize the use of such data and recordings only for the scientific and educational purposes specified above.

Data obtained as a result of this study will be maintained in password-protected computer and Internet files.

My child's name will not appear in any report, publication, or public video that results from this study unless it is my desire and I provide an additional consent in writing.

Precautions are being taken to restrict the use of materials such as videos for educational purposes; however it is not possible to guarantee that distributed materials will always be used for the intended purposes.

I am free to withdraw my consent for my child to participate and my child may decline to be interviewed or recorded at any time, and that no penalty or prejudice toward my child shall result.

Further questions about this project are welcome and should be addressed to:

[Name and contact information for researcher and IRB representative]

____
(Child's Name)

________________________________ ________________________________
(Parent or Guardian Signature) (Date)

Item 2
Consent Form for Adults
Understanding and Cultivating the Transition from Arithmetic to Algebraic Reasoning

In signing this document I agree to participate in a study of instruction and professional interaction being conducted by Dr. Sharon Derry in connection with a project funded by the National Science Foundation titled "Understanding and Cultivating the Transition from Arithmetic to Algebraic Reasoning." I understand that my interactions in professional development classes and in on-line computer discussions related to those classes may be observed and captured by video and other digital recording devices. I know that I may be asked to complete assessment tasks and questionnaires designed to measure my learning and belief change, and that I may be interviewed. I understand these data will be analyzed by social scientists to help them evaluate and improve educational professional development programs. In addition, I understand that video recordings containing my image may be distributed to educational groups and made available to educators on the World Wide Web, for the purpose of advertising project work, training teachers and other educational specialists, and conducting research on teacher learning. I authorize the use of such data and recordings as described above only for the scientific and educational purposes specified above. I have been told that data obtained as a result of this study will be maintained in password-protected computer and Internet files and that my name will not appear in any report or publication resulting from this study. I authorize the mention of only my first name in video recordings. I have been advised that while all feasible precautions are being taken to restrict the use of materials such as videos for educational purposes, it is not possible to fully guarantee that distributed materials, especially those distributed via the Internet, will always be used for intended purposes. I know that during this project I am free to withdraw my consent and decline to be interviewed or recorded at any time, and that no penalty or prejudice shall result.

Further questions about this project are welcome and should be addressed to:

[Name of researcher and IRB contact person]

______________________________ ______________________________
(Signature) (Date)

Item 3
Example Letter to Parent to Accompany Informed Consent Form

Official Letterhead

Date

Dear Parent or Guardian:

Your son or daughter is currently participating in an exemplary science curriculum called Learning by Design, developed by my research team at the Georgia Institute of Technology College of Computing. Funded by the National Science Foundation, the Learning by Design (LBD) project is an important curriculum-development effort that is intended to help improve students' knowledge and test performance in science.

To help us understand and evaluate these new methods and materials and to broadly disseminate them to other schools, I have engaged researchers from the University of Wisconsin-Madison and Michigan State University to help create videos illustrating how your child's specially trained teacher conducts an LBD classroom. Because it is important that researchers and other teachers be able to view and study how an experienced teacher implements the LBD method, I am writing to request your permission to allow researchers to videotape your child's class for the purposes of studying the classroom and developing instructional materials for teacher education. Only with your permission will we create and use videos that contain your child's image.

If you grant your permission, the videos of your child's classroom and possibly containing your child's image will be analyzed and edited by educational researchers. Colleges, universities, and schools will use edited videos to help train teachers. The videos will also be used by researchers to better understand and improve learning and teaching in LBD classrooms. One method of distributing these videotapes will be to incorporate them into a password-protected World Wide Web site that will be accessed by teachers enrolled in programs offering the LBD training and by researchers studying learning within the LBD program. Although it is not possible to guarantee that materials on the World Wide Web will always be used only for the intended purposes, we will take all reasonable precautions to ensure that videos are accessed only by authorized and qualified personnel.

Please indicate whether or not you and your child agree that we may collect video of your child in the classroom by signing the attached form. Your cooperation is very important. It will help improve our nation's teacher preparation programs and our students' competency in science. Thank you in advance for your assistance. If you have any concerns or questions about this request, please do not hesitate to contact me at . . . (phone number).

Sincerely,
[researcher's name and title]

Item 4
Informed Consent for a Minor Child to Participate in Educational Research Related to Learning-By-Design Project

In signing this document my child and I indicate our mutual agreement that he or she may participate in a study of classroom instruction being conducted by Dr. Janet Kolodner in collaboration with Dr. Sharon Derry at the University of Wisconsin-Madison. I understand that my child's interactions in classes may be captured by video and audio recording devices. I understand that video recordings of my child's class and possibly containing images and the first name of my child will be used in research settings, in college classes, and on the World Wide Web for the purpose of training teachers and studying teaching and learning in a Learning-By-Design classroom. I authorize the use of such data and recordings as described above for these scientific and educational purposes. I know that I am free to decline to my child's participation in this study or to withdraw my consent for my child to be recorded and that my child may decline to be recorded at any time, and that no penalty or prejudice toward me or my child shall result.

_____I have discussed the study with my child and we AGREE to these conditions and will participate.

_____I have discussed this study with my child and we DO NOT AGREE to these conditions and will not participate.

____
(Child's Name)

______________________________ ______________________________
(Parent or Guardian Signature) (Date)

______________________________ ______________________________
(Child's signature) (Date)

Further questions about this project are welcome and should be addressed to:

[Name and contact information for researcher and IRB representative]

APPENDIX C. CONFERENCE OR MEETING PARTICIPANTS

Brigid Barron, *Stanford University**
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