Friel, S., & Carboni, L. (2000). Using video-based pedagogy in an elementary mathematics methods course. *School Science and Mathematics, 100*, 118–127.

Hatfield, M. (1996). Using multimedia in preservice education. *Journal of Teacher Education, 47*, 223–228.

Hatfield, M., & Bitter, G. (1997). A multimedia alternative for professional development. *Teaching Education, 8*, 67–71.

Kenny, R., Andrews, B., & Vignola, M. (1999). Towards guidelines for the design of interactive multimedia instruction: Fostering the reflective decision-making of preservice teachers. *Journal of Technology and Teacher Education, 7*, 13–31.

Krajcik, J., & Soloway, E. (1996). The Casebook of Project Practices – an example of an interactive multimedia system for professional development. *Journal of Computers in Mathematics and Science Teaching, 15*, 119–135.

Ladewski, B. (1996). Interactive multimedia learning environments for teacher education: Comparing and contrasting four systems. *Journal of Computers in Mathematics and Science Teaching, 15*, 173–197.

Lampert, M., & Ball, D. (1998). *Teaching, multimedia, and mathematics: Investigations of real practice*. New York: Teachers College Press.

McDevitt, M. (1996). A virtual view: Classroom observations at a distance. *Journal of Teacher Education*, 191–196.

Perry, G., & Talley, S. (2001). Online video case studies and teacher education: A new tool for preservice education. *Journal of Computing in Teacher Education, 17*(4), 26–31.

Rosaen, C., Schram, P., & Herbel-Eisenmann, B. (2002). Using hypermedia technology to explore connections among mathematics, language, and literacy in teacher education. *Contemporary Issues in Technology and Teacher Education, 2*, 2–31.

Schon, D. (1983). *The reflective practitioner*. New York: Basic Books.

Schon, D. (1987). *Educating the reflective practitioner*. San Francisco: Jossey-Bass.

Sharpe, L., Hu, C., Crawford, L., Gopinathan, S., Khine, M., Moo, S., & Wong, A. (2003). Enhancing multipoint desktop video conferencing (MDVC) with lesson video clips: Recent developments in pre-service teaching practice in Singapore. *Teaching and Teacher Education, 19*, 529–541.

Shulman, L. (1992). Toward a pedagogy of cases. In: J. Shulman (Ed.), *Case Methods in Teacher Education* (pp. 1–30). New York: Teachers College Press.

Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In: D. Nix & R. J. Spiro (Eds), *Cognition, Education, and Multimedia: Explorations in High Technology* (pp. 163–205). Hillsdale, NJ: Erlbaum.

Strickland, J., & Doty, K. (1997). Use of videotapes of exemplary mathematics teaching for teacher preparation. *Education, 118*, 259–261.

Teale, W., Leu, D., & Labbo, L. (2002). The CTELL project: New ways technology can help educate tomorrow's reading teachers. *The Reading Teacher, 55*, 654–659.

Wasserman, S. (1994). *Introduction to case method teaching*. New York: Teachers College Press.

Jere Brophy
Series Editor

1. NEW PERSPECTIVES ON THE ROLE OF VIDEO IN TEACHER EDUCATION

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ABSTRACT

This chapter examines the role that video has played since its introduction to teacher education in the 1960s. The chapter first reviews several leading innovations that have been popular across the last forty years. I then argue that in the past, teacher education has not always capitalized on the features of video that make it particularly useful for teachers. To address this issue, I introduce three affordances of video that should be considered when designing video-based activities for teachers. To conclude, I point to several programs that leverage these affordances and that I recommend we investigate for the future.

INTRODUCTION

For decades, teacher educators have looked for innovative ways to help preservice and inservice teachers learn to teach. As video equipment became more portable and less costly in the early 1960s, many believed that this technology now held great potential for improving teacher education (e.g. Olivero, 1965). Soon, universities and colleges across the United States were using videotaped observations of teaching as part of their preparation for new teachers (Levis, 1987). In addition,

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a number of programs incorporated the use of video into professional development activities for veteran teachers (e.g. Woolman, 1969). Watching oneself and other teachers on videotape became a common practice in teacher education and remains so at many institutions today (McIntyre, Byrd & Foxx, 1996; Willis & Mehlinger, 1996). Furthermore, as our technological capabilities expand, it seems likely that teacher education will continue to rely on video as an important means of instruction and evaluation; in fact, the field's emphasis on video may even increase. Why has this been the case? Other innovations have come and gone, yet video persists. What is it about video that teachers find so appealing, and that teacher educators and researchers, despite mixed research results, continue to value? Why does video remain a central component of the training of teachers? And what direction should we take in using video in teacher education in the future?

These are the questions that I explore in this chapter. I first take the reader through a brief review of the history of video in teacher education, highlighting key programs that have been popular over the past forty years. In so doing, I illustrate that the use of video was driven by prevailing theoretical frameworks in education as well as by technological innovations that occurred. With this review in mind, I claim that what has been lacking in most cases is attention to the features of video that make it particularly useful for teachers. For example, video has often been used simply as a substitute for live classroom observations, without careful consideration of how a videotape might provide a different perspective than is possible during a live observation. In contrast, I maintain that we must attend to the unique affordances of video in designing the ways in which we engage teachers with video. In particular, I identify three affordances of video that I believe are relevant for teacher education. To conclude, I discuss five ways of using video with teachers that leverage some of these affordances and that I recommend we investigate for the future.

To be clear, the goal of this chapter is not to survey researchers' claims about what teachers learn through various uses of video in teacher education. Therefore, in discussing selected video-based programs in the next section, I do not review research findings regarding the effectiveness of these programs for teachers. I will simply note here, however, that early reports on the role of video in teacher learning generally found quite mixed results. (See for example, Fuller & Manning, 1973; McIntyre, Byrd & Foxx, 1996.) This suggests that more empirical work is needed to fully understand the role of video in supporting teacher learning. My hope is that the ideas presented in this chapter can serve as a first step toward achieving that goal. Specifically, if we understand the affordances of video for teacher education, then we will be in a better position to know what to look for when examining teacher learning via video.

SELECTED USES OF VIDEO IN TEACHER EDUCATION

Microteaching

One the earliest applications of video to teacher education was the development of microteaching. As its name implies, the goal of microteaching was to experiment with teaching at a micro-level – teaching was scaled down in terms of instruction time, class size, and instructional strategies used. At the beginning of a typical microteaching session, the participant was introduced to a specific teaching skill such as lecturing or leading a discussion. The participant then taught a brief lesson, between five and ten minutes, to a small group of students who were often peers. The assumption was that teaching a lesson under these conditions allowed the participant to focus his or her efforts on the teaching skill that had been identified. Video feedback was also an important part of the microteaching process. The lesson itself was videotaped and immediately following, the participant used the video to analyze his or her success with the selected skill. In some cases, the participant watched the video with a supervisor. Either way, the next step was for the participant to restructure the lesson as needed and reteach the lesson to a new group of students. The cycle of reteaching and video analysis continued until the participant demonstrated mastery of the focus skill.

For example, Borg (1972) explored the use of microteaching to modify the ways in which inservice teachers conducted whole-class discussions. In one case, teachers were introduced to a set of probing techniques including prompting students with cues, asking students for further clarification, and helping students relate their responses to other relevant topics. Participants explored the techniques using a set of example questions and by viewing a demonstration in which the probing strategies were used. Next, the teachers were videotaped as they practiced using the questioning skills with a small group of students in a shortened class period. Following this, they analyzed their own use of the probing strategies using the video. Each teacher participated in several cycles of filming and viewing.

Microteaching was based on a behaviorist view of teaching, the central tenet being that teaching is a well-defined activity consisting of a set of skills to be practiced and learned. In particular, microteaching was seen as a way to simplify the act of teaching so that trainees could practice (and master) the individual skills that were the basis for effective teaching. Microteaching was developed in the early 1960s in parallel to the introduction of portable video equipment (Olivero, 1965). It seems likely that, at least in part, the development of microteaching was a response to the growing availability of video equipment. Microteaching soon became the standard for teacher education programs nationwide. By 1972, over

100 studies had investigated the effects of microteaching (Levis, 1987). Much of this literature reported mixed results in terms of the influence of microteaching on participants' teaching practices. Nevertheless, microteaching maintained its status as an effective tool for teacher education for over two decades and effectively launched the use of video in teacher education.

Interaction Analysis

In the 1970s, a second use of video in teacher education gained popularity. This method, called interaction or lesson analysis, involved training teachers to use an observation instrument in the analysis of teaching. Such instruments laid out a specific set of behaviors that participants were to look for on the video. Thus, unlike microteaching where participants had an opportunity to practice a specific skill, here participants learned to identify particular student and teacher behaviors. In addition, participants used their coding of the video to evaluate the effects of specific behaviors. For example, participants might have compared the relative amounts of praise and criticism given by the teacher in relationship to the amount of student talk in the classroom. One of the most popular systems used in this context was developed by Flanders (1970) in which classroom interaction was divided into ten distinct categories of observable teacher and student talk. A number of other systems were developed and used as well, many of them modifications of Flanders' original work.

Like microteaching, interaction analysis had its roots in the idea that the complexity of the classroom can be broken down into a number of component parts. In addition, interaction analysis drew heavily on the perspective of process-product research. Thus, one of the goals of the program was to introduce teachers to specific relationships between teacher behaviors and student outcomes. As before, the focus was on *what* practices teachers should use and not on *why* these practices were effective.

Strictly speaking, interaction analysis was first used in teacher education before microteaching and the advent of video. In its original form, interaction analysis did not use video and instead relied on audiotapes, slides, and transcripts of classroom interactions (Cruickshank & Metcalf, 1990). However, with the introduction of the video camera to teacher education, interaction analysis became much more feasible. Video greatly simplified the process involved and as a result, increased the prevalence of interaction analysis as a method of training teachers (Wragg, 1987). Thus, video played different roles in the development of microteaching and interaction analaysis. Microteaching was largely developed because of the availability of video while interaction analysis was adapted to incorporate the use of video.

Modeling Expert Teaching

As behaviorism gave way to cognitive psychology in the early 1980s, researchers and teacher educators began to focus more on the ways in which teachers *think* rather than on the ways in which teachers *behave*. The idea that teaching was a complex, ill-structured activity gained momentum and expert teachers were seen as having rich resources to draw on during instruction (Berliner, 1986). One implication for teacher education was the idea that novice teachers could learn from studying the practice of more expert teachers. As a result, teacher education programs began to include two types of opportunities for preservice teachers to examine the teaching of more experienced teachers. In the first, expert teaching was modeled for novices through videotapes of actual instruction. In some cases, videos of both novice and expert teachers teaching the same lessons were compared. The idea here was that by studying the instructional strategies and methods of expert teachers, novice teachers could become more expert themselves.

In the second model, excerpts of video were shown to novice teachers along with videotaped commentary on the lessons by expert teachers. Rowley and Hart (1993) used this technique to try to address issues identified as common problems for beginning teachers. For example, prospective teachers were initially shown a videotape of a novice teacher struggling with classroom management at the elementary school level. Following this, they were shown a video of the novice teacher discussing her concerns with a more experienced mentor teacher. Finally, the prospective teachers were asked to make recommendations concerning how the novice teacher should proceed. The goal of this program was for the prospective teachers to learn from hearing the expert teachers talk about *why* it is they do what they do. Expert teachers were found to have more complex schemas for interpreting classroom activity than do novice teachers (Berliner, 1994; Leinhardt & Greeno, 1986). Therefore, their comments on instruction were expected to raise issues that might otherwise not have been considered by the prospective teachers (Copeland et al., 1994).

The use of video to model expert teaching illustrated the beginning of an important shift in research on teaching and in teacher education. On the one hand, expert teachers and effective teaching practices were usually defined as such on the basis of student test scores. This represented the field's continued interest in the relationship between teacher behaviors and student outcomes. However, there was also evidence of the field's emerging interest in teacher cognition. The focus on expert teachers reflected an attempt to look beyond teaching behaviors and examine the "wisdom of practice" – how expert teachers made decisions in the classroom and the knowledge that served as the basis for those decisions (L. Shulman, 1987).

Video-Based Cases

By the late 1980s, research on teacher cognition was in full swing and behaviorism had lost much of its hold on the field. Teacher education programs began to look for new models of innovation, and many chose to experiment with case-based pedagogy. Similar to the use of cases in business and law, teaching-cases were designed to provide novice teachers with rich examples of pedagogical dilemmas. Cases were presented as text-based narratives, and in some instances included commentaries. Both preservice and inservice programs were developed in which groups of teachers would participate in a series of "case discussions" guided by a facilitator.

For example, Barnett, Goldenstein and Jackson (1994) developed a set of mathematics teaching cases. One case examined the confusion that can arise between the language used to describe subtraction and multiplication. The case consisted of a three-page narrative in which a teacher described how her students responded when asked to draw a picture "where you take $\frac{1}{3}$ of $1\frac{1}{3}$" (p. 4). While some students attempted to model division, others simply subtracted one-third. The teacher had not anticipated this confusion and was unsure of how to proceed. In discussing this situation, the teacher explained how the class had explored fractions up to this point. Finally, in the conclusion of the case, the teacher questioned whether or not it had been appropriate to have students explore division of fractions without being given more explicit directions. A facilitator's guide suggested a range of issues that could be discussed after reading this case including the mathematical ideas raised by students, the language involved in division, and how a teacher might respond to students' incorrect solutions. Other case materials examined a diverse array of topics including problem solving and mentoring new teachers and, similar to the case described above, raised a host of related issues for teachers to explore as they discussed the case (J. Shulman, 1992; J. Shulman & Colbert, 1987; Silverman, Welty & Lyons, 1992).

Case methods reflected the field's growing interest in not only what teachers know but in how that knowledge is represented. Specifically, cases were thought to provide teachers with relevant knowledge about teaching in a format that was useful. Not only were they based in the context of teaching, but because of our tendency to hold knowledge in chunks, the hope was that cases could be easily indexed and recalled by teachers. Furthermore, teacher educators expected work with cases to help novice teachers become accustomed to reflecting on teaching and to aid in the development of professional problem-solving strategies. Cases also illustrated the perspective that teaching was complex and that teachers must manage multiple tensions simultaneously (Lampert, 1985, 2001).

It was not long before researchers and teacher educators began to explore the viability of video-based cases. By the mid-1990s, a handful of teacher educators had developed teaching cases which were presented to preservice teachers via video rather than in a written form. For instance, Copeland and Decker (1996) discussed their use of a video case in which a fourth-grade class was involved in reading instruction. The case consisted of a four-and-a-half minute video in which a teacher sat with a small group of students and discussed the predictions that students had made based on their reading assignment. The teacher asked the students to locate evidence in the reading to support their predictions. Copeland and Decker noted that the case raised a variety of related issues including the nature of student participation in discussion, the questioning techniques used by the teacher, and the balance of teacher to student control.

Similar to narrative cases, the goal was to use video-based cases as the basis for reflection and for the development of teachers' professional knowledge base. The introduction of video-based cases demonstrated the field's long-standing interest in using video in teacher education. Here was a situation where an existing, and successful, innovation was adapted in order to incorporate video. However, unlike interaction analysis where the introduction of video greatly increased the prevalence of the innovation, video-based cases did not become an industry standard. Narrative cases continued to be the most popular form of case methods in teacher education (Merseth & Lacey, 1993; J. Shulman, 1997). Perhaps this is because, unlike video, written cases distill what happened in a story-based format. In so doing, narrative cases can provide background and contextual information, as well as a first or third person reflection of the unfolding pedagogical dilemma.

Hypermedia Programs

In the early 1990s hypermedia programs for teacher education began to appear in which video was linked to text and graphics. These programs typically consisted of laserdiscs in which excerpts of video were connected electronically to HyperCard stacks that framed different issues for preservice and inservice teachers to examine (e.g. Goldman & Barron, 1990; Krajcik & Soloway, 1996; Lampert, Heaton, & Ball, 1994). Hypermedia programs provided teachers with the opportunity to access video in different ways. There were usually multiple starting points and multiple paths that a user could take to explore the data provided. In particular, video segments could be viewed in any order, not just chronologically as was the case with videotape. Most hypermedia programs were designed to support teacher learning of particular ideas such as project-based science or standards-based mathematics instruction. In fact, users were typically presented with video to examine alongside a framework that served to guide their exploration. Hypermedia programs have gained in popularity over the past decade, with many systems now available on

CD. The majority of programs today continue to provide opportunities for teachers to analyze and compare video segments in the context of a given framework.[1]

For example, "Teaching Mathematics Methods Using Interactive Visdeodisc" (TMMUIV) (Hatfield & Bitter, 1994) attempted to train teachers to use manipulatives in teaching elementary school mathematics. The program consisted of a video database comprised of segments from actual classroom lessons as well as from university presentations. The video excerpts were organized in terms of: (a) manipulative shown; (b) mathematical concept addressed; (c) teaching method used; and (d) level of reasoning displayed by the students in the video. One way to use the system was for the user to select particular subfields of interest (e.g. base-ten blocks, addition, guided discussion, high-order convergent reasoning) and then view the corresponding video segment. In a second mode, "presentations" were suggested for instructors that linked objectives, activities, and related video excerpts. Third, the system offered a set of individualized learning programs that guided the user through the system in order to examine, for instance, contrasting teaching methods or the range of student conceptions about particular mathematical concepts. In so doing, the system provided for multiple observations, review, and discussion of particular video excerpts.

Unlike the other uses of video that I have described so far, the causal factor for the introduction of hypermedia to teacher education was the advent of technology, in particular, advances in computer technology and the ability to digitize video. Prior to this time, one was restricted to a single sequential presentation of video. Jumping from one point to another was quite slow, and the norm was to watch a videotape from beginning to end. In contrast, when a video is digitized, one can move from point to point rapidly and there can be multiple organizations and presentations of the same video material. Such features were quickly capitalized upon in the development of hypermedia programs for teacher education. While I have emphasized the role that technology has played in the introduction of hypermedia to teacher education, current thinking about teaching and learning have certainly also played a role, particularly in recent designs. For example, new hypermedia programs often provide a richer picture of the context in which teaching events occur than has been provided in the past. In this way, teaching events are not viewed as isolated and it is possible to see them as situated in a broader context (Bowers & Doerr, 2001).

Field Recordings

Before concluding this section, I want to mention one more approach to using video with teachers that deserves attention – the recording of field observations. Interestingly, this use of video has remained constant throughout more than three

decades. However, the way that teacher educators have looked at field recordings has changed over time. For example, some of the earliest reports of using video in teacher education claimed that one advantage of video was the ability to substitute live observations with videotaped supervision (Olivero, 1965). The idea was that this would save on the supervisor's time without detracting from the supervisor's feedback. Today, the reasons given for field recordings are pedagogical as well as managerial. For example, rather than provide a student with solely written feedback on an observation, supervisors may use segments of video to illustrate a point and may watch portions of a videotape with the student. In addition, field recordings from student teaching are often used for group reflection. In some university courses, preservice teachers prepare a presentation based on video of their teaching for their supervisor and peers.

Veteran teachers have generally been videotaped with less frequency, though this is becoming more common as a part of new professional development programs. For example, teachers who apply for certification from the National Board for Professional Teaching Standards are required to submit videotapes of their teaching along with written commentaries. In 2002 alone, 7,893 teachers received such certification. Other programs have also been developed in which veteran teachers watch videotapes of their classrooms. In some cases, teachers are videotaped and discuss their teaching individually with a researcher (Richardson & Anders, 1994). In other instances, veteran teachers share excerpts of video with their peers in order to raise particular issues for discussion (Achinstein & Meyer, 1997; Sherin & Han, in press; Tochon, 1999). Such designs attempt to use the context of the group viewing of the field recordings as an important context for teacher learning.

Looking Across Selected Uses of Video in Teacher Education

Examining the different uses of video that have become part of the teacher education landscape over the past forty years reveals a number of interesting patterns. First, it is evident that the purposes for and manner in which video has been used in teacher education has changed over the last four decades. From microteaching to hypermedia programs, video has proved itself to be a flexible medium, adaptable in both form and function. Second, changes in the use of video over this time have been driven to a large extent by changes in leading theoretical frameworks in education. In particular, the shift in perspective from behaviorism to cognitive views of teaching was reflected in changes in the role of video in teacher education. Third, technological innovations have also influenced the ways in which video has been used with teachers. Just as the initial availability

of portable video cameras stimulated a variety of uses, the possibility of viewing video as digitized on a computer was followed by new innovations.

Despite these many changes, the idea that it is useful for teachers to be videotaped and to view videotapes of teaching has remained constant. Watching videotapes of instruction has been found to be motivating for teachers, and in some cases to promote change in teachers' practices. It appears that video has become a permanent fixture in teacher education. What is surprising however, is that despite its extensiveness, the use of video in teacher education does not always reflect an understanding of precisely what it is about *video* that might provide support for teacher learning. In the next section of this chapter I address this issue by exploring some of the key features of video and by considering how they might enhance teachers' reflection and analysis of classroom interactions.

AFFORDANCES OF VIDEO FOR TEACHER EDUCATION

Here I begin to examine more closely what it is that video has to offer teacher education. Specifically, my goal is to consider some of the unique characteristics of video and the corresponding opportunities for teachers to examine classroom interactions. Before focusing on the affordances of video, however, it will be useful to discuss some of what is *not* afforded by video. First, a person viewing a video of a classroom is placed in a passive role. Unlike the teacher or even an observer, the viewer has no opportunity to interact with the participants who appear on the video. Instead, what is shown on the video is precisely what the viewer has the opportunity to observe; there is no chance to ask a student to repeat an answer or to elaborate an idea.

Second, the information captured by the video camera may be much more limited than if someone were observing in a classroom live. As an observer or teacher, you decide what deserves attention, and you might decide to pay attention to multiple aspects of classroom interactions at once. For instance, while sitting with one group, you may still have a sense of what is happening with the rest of the class, whether the level of noise and activity has increased or decreased, and whether or not students are still engaged in the task at hand or are ready to move on to the next part of the lesson. In contrast, the video camera looks in only one direction at a time. And when the camera is focused on the class as a whole, it can be difficult to see or hear what individual or groups of students are doing. Moreover, there is no opportunity to turn your head to look around and see what else is going on in the classroom. This difference between observing a classroom live and via video may be especially pronounced for experienced teachers and observers who are skilled

at noticing significant features of classroom interactions (Berliner, 1994; van Es & Sherin, 2002). Novice teachers, on the other hand, may have more difficulty determining which aspects of classroom interactions demand close attention, and thus may be less constrained – or might even be helped – by this limitation of video.

Third, a videotape of a lesson does not necessarily capture the wide-variety of contextual information that underlies people's actions and comments. It does not capture, for example, what happened a day, a week, or a month earlier. Neither does it reveal the broader atmosphere of the school or what students are doing in other classrooms. Lampert (2000, 2002) emphasizes the importance of contextual information of this sort for interpreting classroom events. She explains that a teacher in his or her own classroom is likely to have much more information about what is happening than is revealed in a video. Goldman-Segall (1998) also emphasizes the importance of context in making sense of a videotape of a classroom. Yet rather than focus on the additional information that the teacher is likely to possess, Goldman Segall argues that the videotape itself does present not an unbiased view of a classroom, but is instead a product of the videographer's perspective.[2]

Despite these drawbacks, for the moment I will focus on the affordances of video – and on three sets of affordances in particular: (a) video is a lasting record; (b) video can be collected, edited, and recombined; and (c) video sustains a set of practices that are very different from teaching. The first two of these affordances draw from the work of Latour (1990) in examining the relationship between inscriptions and scientific practice. The third is based on my own research with video-based professional development (Sherin, 1996).

Video is a Lasting Record

Video is immutable (Latour, 1990); it offers permanence and provides a lasting record of classroom interaction. Furthermore, this record can be played again and again; it can be paused and rewound. One can return to a particular student statement repeatedly, one can freeze the video on a student's drawing, or one can revisit a specific conversation multiple times.

As a teacher, this permanence offers a number of opportunities. First, if it is your own classroom that is videotaped, then you do not have to rely on your memory of what happened. Instead you can refer to the video for clarification of what took place or for an additional perspective. Second, the permanence of video allows the viewer to select a particular focus of attention. Thus, one can decide to attend to some things when watching the video and not others, knowing that one will have an opportunity to return to these other issues in the future. The video will still be there and will contain exactly the same information.

Related to these two opportunities is the fact that the lasting record provided by video does not necessarily duplicate the information one would receive during a live observation. In contrast, in some ways, video provides better access to classroom practices than a teacher or an observer usually has. With the aid of external microphones, one can listen to small-group interactions unobtrusively, or can overhear conversations between the teacher and an individual student. In addition, one can truly have "eyes in the back of one's head" and can see explicitly what happens when the teacher's back is turned. Similarly, one can observe the interactions of a small group of students at the same time as you were interacting with another group of students.

Most of the innovations described in the previous section made use of video's permanence in some sense. The fact that the video captured the teaching act was critical for microteaching; video provided the participant access to his or her own practice. Similarly, interaction analysis relied on video as a record of practice. Because it could be difficult to apply the observation system in real time, the fact that the video could be paused was particularly useful. Yet for the most part, these innovations did not take advantage of the most powerful aspects of video's immutability. Video was not typically played and replayed. In microteaching, for example, the video is viewed and then the participant reteaches the lesson. Neither was it typical for teachers to view a video multiple times with different perspectives. In contrast, most of the innovations asked teachers to view the video only once, and with a particular perspective in mind.

Video Can be Collected and Edited

The second affordance of video that I describe has recently been emphasized by sociologists as an important feature of external representations (Latour, 1990). Video can be collected, edited, and reorganized into a format that differs from its original presentation. Though video initially presents a chronological progression of classroom interaction, this is not the only form in which the material can be stored. For example, video editing permits a class period to be divided into segments, some of which may be deleted, others of which may be rearranged. The capability to digitize video has enhanced these opportunities even further. Specifically, with digitized video, one can jump between different locations in a video instantaneously. One implication for teacher education is the possibility of creating video libraries (Frederiksen, 1992). Such libraries could include collections of video excerpts around particular themes such as homework review and classroom discourse. Thus, teachers would no longer have to watch a linear progression of lessons, and instead could access excerpts of video around a particular topic.

In addition, video can be integrated with other media such as graphics and text. For example, classroom video can be linked electronically to curriculum materials, to student work, and to teacher reflections. Given current advances in technology, such environments are becoming increasingly popular and powerful.

The hypermedia programs described earlier clearly took advantage of the ability to combine video with different media and to edit and collect selections of video. The user had access to a number of video segments, while text and graphics presented commentary and background on these segments. However, for the most part, these initial programs tended to provide only limited access to video. The programs were usually organized around investigations of particular teaching methods or philosophies and links to video segments directed the user to these goals. As a result, such programs did not take full advantage of the ways in which video can be stored and indexed in order to promote multiple paths of inquiry.

Video Affords a Different Set of Practices

A third important characteristic of video arises as a result of the permanence and editability of this medium. With these two features in place, it is possible to design a new set of practices for teachers based on repeated viewings and reorganizations of video. I will give examples of such practices in a moment. First, however, I want to explain that in general, these practices involve what I call an "analytic mind-set." They offer the opportunity to analyze teaching in ways that are very different from the types of practices and responsibilities that are usually a part of teachers' daily work. In particular, video allows one to enter the world of the classroom without having to be in the position of teaching in-the-moment and to manipulate that world in ways not possible without the video record. Putnam and Borko (2000) suggest that teachers' actions in the classroom are constrained by familiar routines, and that their thinking may have become routinized as well. While some automation is an important indicator of teacher expertise, it can also constrain teacher learning (Berliner, 1994; Sherin, 2002). Putnam and Borko argue that teachers need to engage in new types of learning experiences in order to "break set" – that is, to consider teaching and learning in new ways. I claim that video offers teachers the opportunity to do just that – to engage in a unique set of practices. Three examples follow.

First, when watching a pedagogical dilemma on video, one does not have to respond with the immediacy required when in the classroom live. Video affords the luxury of time. Thus, a student's comment or action on video can be a subject for reflection rather than for action. The video can be stopped at that moment and one can spend time exploring a variety of options. In fact, the goal need not be to

decide how to proceed in the classroom or to evaluate the path taken by the teacher on the video.

Second, viewing video opens up the possibility of seeing alternate pedagogical strategies. Too often teachers' work is conducted in isolation (Little, 1993) with little time and access to their colleagues' work. In contrast, through video, teachers can gain access to different classrooms and to a wide variety of instructional strategies, curricula, and classroom cultures. Moreover, because teachers at the same school site share a student population and may use similar curriculum materials, the possibilities for viewing practices different from one's own are far greater via video than through observations alone. Thus, video affords the opportunity to view alternate practices, and to compare and contrast different teaching styles and teaching strategies.

Third, similar to the role that video plays in educational research, video provides teachers the opportunity to engage in fine-grained analyses of classroom practice. For example, video can become a resource for teachers to use to consider how students think about a specific concept and how students wrestle with ideas in particular contexts. This is very different from the kind of analysis teachers conduct during instruction. Using video, teachers can spend an extended amount of time analyzing a small portion of classroom practice.

The preceding three examples illustrate teachers engaged in practices that are very different from typical pedagogical practices. The main point here is that watching video affords the opportunity to develop a different kind of knowledge for teaching – knowledge not of "what to do next," but rather, knowledge of how to interpret and reflect on classroom practices. In contrast, the use of video in teacher education has focused mainly on the development of teaching skills. Thus, video was used to analyze one's own or another's teaching practices and to determine the effectiveness of a particular pedagogical approach. Alternatively, participants were asked to put themselves in the role of teacher and to decide what to do next. While these are valuable activities, they do not use the video to help teachers develop a new way of interpreting classroom interactions. Interaction analysis comes closest to the type of activity I describe here, yet it offers teachers only a limited approach to the analysis of video.

REDEFINING THE ROLE OF VIDEO IN TEACHER EDUCATION

Having introduced the preceding affordances of video for teacher education, the next step is to examine whether and how current video-based programs for teachers take advantage of these affordances. Towards that end, I discuss five applications

that I think are sensitive to the affordances of video described above. To be clear, I am not making claims about the effectiveness of these types of programs for teacher learning. In other work, I argue that the role of video in supporting teacher learning is not well understood, and that further research in this area is called for (Sherin, 2001). Here, however, my goal is to illustrate the ways in which several current video-based programs make use of the affordances of video and to suggest that, because of this, they are likely to be interesting avenues to investigate in the future.

The five applications that I discuss cover a range of approaches to using video with teachers. They vary, for example, in the amount of video that is available to be viewed and in whose video is shown. Specifically, some of the programs allow teachers to view video of their own teaching and some focus exclusively on the viewing of other teachers' practices. Another difference among the programs is the extent to which technology supports the viewing of video, that is, whether video is embedded in a larger multimedia program or is used in a stand-alone format. Related to this, some of the programs rely on new technological innovations that are not yet readily available to teacher education today. Thus, some of my recommendations can be thought of as "virtual suggestions" that will hopefully become more feasible in time.

Video Clubs

As mentioned previously, the recording of field observations is a common occurrence in teacher education. Yet how those recordings are used varies greatly. The approach I want to highlight here is the use of *video clubs*. In a video club, a group of teachers meet regularly to watch and discuss video excerpts from their classrooms. In a typical arrangement, a researcher, who acts as a facilitator for the group, videotapes the participating teachers' classrooms periodically. The teacher and facilitator then select a short excerpt of video to show to the group. In the video club meeting itself, the teachers view the video excerpt and discuss those issues in the video that appear salient to the teachers.

For example, in one video club comprised of middle school mathematics teachers, the teachers met monthly for an entire school year, taking turns bringing excerpts of whole-class discussions for the group to watch (Sherin & Han, in press). On one occasion, the group viewed a discussion in which students argued for different interpretations of a given graph. In commenting on the excerpt in the video club, the teachers discussed a range of ideas concerning what they had noticed in the video. They began by discussing the teacher's goals for the lesson and then discussed three specific ideas that students had raised about the graphs.

Next, the teachers discussed the mathematical concept underlying one student's claim and offered different interpretations of the student's statement.

Video clubs rely on the permanence of video in order to represent classroom practice and to provide a format where a brief excerpt of teaching can be viewed repeatedly. But where video clubs take particular advantage of video is in engaging teachers in a new set of practices. In my own work with video clubs, I found that teachers responded quite differently to situations that appeared on the video as compared to how they typically responded during instruction (Gamoran, 1995). For instance, during instruction, teachers often focused on deciding what to do next and on carrying out those decisions. In contrast, when watching themselves and their colleagues in the video club, the same teachers discussed possible reasons behind various decisions made by the teacher on the video, and they considered alternative instructional strategies that the teacher might have wanted to use in class. In addition, in the video clubs, the teachers worked to develop explanations for students' comments whose meanings had not been clear to them during instruction (Sherin, 2003). Such detailed analyses of students' thinking went beyond the on-the-spot analysis that the teachers typically considered in the midst of instruction.

Furthermore, the new practices that are accessible to teachers in video clubs may change over time. For example, in studying the year-long video club mentioned previously, my colleague and I found that the teachers developed increasingly complex ways to examine the ideas that students raised (Sherin, 1998; Sherin & Han, in press). Specifically, initially teachers commented on a student's idea by simply repeating what a student had said. "Sam says it's [graph] b." Later on, however, the teachers began to analyze the meaning of students' statements. "I don't understand what he means by 'get wider on the graph.' I mean, what's he thinking?" They would also synthesize and generalize from among the different ideas that students had mentioned. "There's a lot of different ideas about correlation here." In addition, we found that over the course of the video clubs, the teachers began to discuss pedagogical issues in new ways. In the early video clubs, the teachers' discussions of pedagogy focused solely on the teacher – the teacher's goals, actions, and decisions. Yet over time, this isolated focus on the teacher shifted. Instead, the teachers came to closely connect discussions of pedagogy with their analysis of student thinking. They began to consistently relate comments about the teacher's role and the teacher's actions in terms of the mathematical ideas that students raised in class. "So maybe the teacher brought up this idea of 'a steep slope' to get students to see the difference between those graphs." In this comment, it is not just the teacher's actions that are being investigated, but rather how the teacher is seen as responding to students' ideas.

Thus, video clubs offer teachers a format in which they can engage in practices that are quite different from their typical instructional practices. Moreover, the practices that are available to teachers in a video club may even change over time as they develop new ways to examine issues related to student thinking and pedagogy. Interestingly, these new practices can have implications for subsequent instruction. For example, teachers reported being more aware of student comments that arose during class after focusing heavily on student thinking in the video clubs (Sherin, 2001; Sherin & Han, in press). In addition, some teachers implemented pedagogical strategies that they had previously viewed in a video club (Sherin, 2003).

Though the use of video clubs is not widespread, it is becoming more common especially as a form of professional development for inservice teachers (Thomas et al., 1998; Tochon, 1999). This trend may be related to research that suggests that video clubs can be a valuable form of support for those teachers who are developing portfolios for submission to the National Board for Professional Teaching Standards (Frederiksen, Sipusic, Sherin, & Wolfe, 1998). In addition, there is some indication that teachers in the United States are beginning to explore a Japanese model of professional development called *lesson study* (Lewis, 2000). In a lesson study, teachers collaboratively plan a lesson over an extended period of time. As part of the collaboration, components of the lesson are implemented by one of the teachers while the rest observe and videotape the lesson. The videotape then becomes a central tool for the group's continued examination of the lesson.

Hypermedia Representations of Practice

Here I return to the use of hypermedia in teacher education. As previously explained, much of hypermedia has made limited use of the ability to catalogue and recombine video with other media. Rather than provide the user with diverse access to massive amounts of data, this technology is used primarily to present a particular dilemma or to illustrate a specific kind of teaching process. In contrast, Lampert and Ball (1990, 1998) envision using hypermedia technology quite differently. They explain that hypermedia "makes multiple perspectives on a real teaching and learning situation available to users [and] can be designed to highlight aspects of a teaching and learning situation without closing off the learner's access to other elements which define its complexity," (Lampert & Ball, 1990, p. 6). They designed their "Mathematics and Teaching through Hypermedia" (M.A.T.H.) system with these goals in mind.

M.A.T.H. provides access to a variety of types of data collected during one year of both Lampert's and Ball's teaching. The system focuses on three selected time periods within the year. For each period, there are videos of classroom instruction along with interviews of the teacher and students. The students' own work is

included in the system as well as the journals kept by Lampert and Ball over the course of the year. In addition, transcripts of the videos are provided.

Ball and Lampert and their colleagues have used the system in mathematics methods courses for preservice elementary teachers. Prospective teachers first selected an issue that they wanted to investigate using the multimedia records of practice. They then collected evidence related to this issue using the M.A.T.H. system. Finally, through organizing this evidence, the prospective teachers formulated an initial conjecture about the question or issue under investigation. Typical projects examined the teacher's role in the classroom and explored how the teacher responded to incorrect answers or chose particular problems to use in class (Lampert & Ball, 1998).

I argue that M.A.T.H. extends other hypermedia environments because its design does not limit the ways in which the user can access and manipulate the data provided. For example, rather than embed the system with questions for the user, Lampert and Ball invite their teacher education students to use the system as a way to explore the students' own questions. Furthermore, a central goal is for the students to use data within the system to support their claims. Thus, M.A.T.H. not only draws on the opportunity to organize video with other sources, it also fosters the development of teachers' ability to interpret classroom practice.

Some systems include an intermediate amount of structure; they do not strongly guide users, yet they do more than simply provide a large database of video and related information. For example, the goal of the "Living Curriculum" project was to design an environment that would support teachers' work with a specific project-based science curriculum (Shrader, 2000). The curriculum materials themselves are embedded within the system, along with video of the materials being implemented and commentaries by the teachers who appear in the videos. What is unique about this system is that it is designed to support teachers as they, themselves, enact the curriculum. A teacher can use the system to examine issues that arise during their own practice – for example, to find out more about a particular lesson, or to explore students' ideas about a given topic. To manage these kinds of investigations, the "Living Curriculum" provides multiple entry points for analysis, while still preserving the nature of the data. Thus, it is designed for a moderately focused task, but still leaves a great deal of room for diverse uses.

In another approach, the hypermedia program "Making Weighty Decisions" (Bowers & Doerr, 2001) was designed to be used with varying degrees of structure. While the overall goal of the program is quite specific – to help pre-service teachers examine the teaching and learning of middle-school statistics – the program allows for multiple ways to pursue this goal (Bowers, under review). For example, the materials include a facilitator's guide that offers explicit directions for organzing teachers' investigations of the video provided. Yet in addition, a much less-structured approach is possible in which the user defines his or her own issues to investigate. To support this approach, the program includes several analytic tools including a searchable database and an "issues matrix" that allows the user to record how different elements of data address a particular idea or theme.

Though their designs differ, all three of these hypermedia programs capitalize on the affordances of video. They take advantage, to a large extent, of the ability to organize and present video and related data in multiple formats. In addition, they put complex representations of practice into the hands of teachers and therefore, allow teachers to explore teaching and learning in new ways.

Video Analysis Tools

A third approach to using video with teachers is to provide a hypermedia tool that allows teachers to work with their own video and to create analyses within the computer system. For example, Video Paper Builder (DiMattia, 2002; Nemirovsky et al., under review) offers an integrated format in which teachers can develop custom analyses of video. The system allows teachers to import digitized video from their own classrooms and to develop a "video paper" in which selected portions of video are linked to transcripts and to commentaries. Illustrations of handouts or student work can also be synchronized to appear as the video is played. In addition, teachers can include links to outside sources on the internet that are relevant to the lesson displayed.

Video Paper Builder makes use of the affordances of video in a way that is somewhat different than has been discussed thus far. Here the ability to edit and combine video data with text and graphics is placed in the hands of the user. This is in marked contrast with other hypermedia programs that use these capabilities in order to organize information that a user will subsequently examine but not modify.

Like Video Paper Builder, VAST (for Video Analysis Support Tool), shares the goal of helping teachers to create their own analyses of video. However, rather than emphasize the infrastructure needed to present this analysis to others, as in a "video paper," VAST attempts to guide the process of analysis in which teachers engage (van Es & Sherin, 2002). Using VAST, teachers insert digitized video from their own classroom along with a transcript and a corresponding classroom handout. Then, VAST provides a set of prompts designed to encourage teachers to notice significant features of classroom interactions. These prompts serve two important roles. First, they direct teachers to focus on aspects of classroom interactions that are thought to be of particular importance in the context of educational reform – student thinking, discourse, the teacher's role, and content (e.g. National Council of Teachers of Mathematics, 2000). As teachers comment on a video, they must select

one of these four topics as being the focus of their comment. Second, within each of these areas, teachers are asked a specific series of four questions intended to help them pay attention to and interpret classroom interactions in a distinct way. Teachers are first asked "What do you notice?" In other words, they are asked to identify what they see as noteworthy in the video excerpt. Next, the teachers are prompted for evidence of what they notice. Here a teacher may choose to link his or her comment to the transcript of the video and/or to a certain moment in the video excerpt. Third, teachers are asked to interpret what they noticed, that is, to provide an analysis of what they think is happening at this point in the video. Fourth, teachers are asked to list any questions that they might want to explore in further analysis.

Helping teachers "learn to notice" is particularly important in light of recent educational reforms. Teachers today are often asked to make decisions about how to proceed with a lesson in the midst of instruction. Yet for many teachers, doing so effectively requires that they develop new techniques for making sense of what is happening in their classrooms; hence the need to "learn to notice." Furthermore, video seems particularly well-suited to aid in this process. Video provides a window into classroom interactions, but without the immediate pressures that one faces during instruction. The design of VAST attempts to capitalize on this by using guided reflections on video as a way to foster teachers' ability to notice and interpret classroom interactions (Sherin & van Es, 2002; van Es & Sherin, 2002).

Research on the use of VAST shows that teachers can develop new ways to analyze classroom interactions as a result of using the system (van Es & Sherin, 2002). In particular, examining a group of six secondary mathematics and science pre-service teachers revealed that they shifted in their analysis of classroom interactions from a straightforward chronological description of a lesson to a description that highlighted key elements of what took place – for example, an interesting student idea, an unexpected turn in a lesson, or a new way to understand a mathematical concept. In addition, teachers who used VAST came to be much more specific in their descriptions of a lesson, moving from generalizations such as "students were engaged" to more specific comments that explained what in the video provided evidence of student engagement. Thus, VAST provided teachers with an opportunity to engage in a new set of practices, practices that developed from a structured approach to commenting on video from their own classrooms.

Extended Records of Teaching Practices

I now turn briefly to two considerations for the use of video in teacher education that are more speculative. First, I recommend that we consider using video to document teaching over an extended period of time. While this is already done in the context

of many research projects, what I am suggesting is that teachers should be able to document their teaching via video over the course of their teaching careers. Keeping such a record manageable would require digitizing video, a process that is becoming more feasible with time. Such a record could take advantage of all three affordances of video that were mentioned previously. It would preserve a record of one's practice over time and would be embedded in a system that allowed random access to the video. In addition, engaging with the system would provide opportunities for teachers to participate in new types of practices.

There is already evidence that developing video portfolios with a few video examples is a valuable professional development activity (Frederiksen, 1992). I suggest that these extended records would be even more promising. Teachers could write commentaries on lessons and link them to the video of the lesson. They could refer back to the video to prepare for teaching a related lesson in the future. Similarly, rather than relying on their impressions of how a student or a class changed over time, they could review video segments. Clearly, it would take serious thought to make such a system useful for teachers given the heavy time constraints under which they currently work. But the possibility remains that such a record could become an important part of a teacher's professional identity. It would keep track of their work over time and provide access to this work in a variety of ways.

Video Networks

As our ability to digitize video becomes more accessible, it will be possible to store video on the computer and to share video across the Internet. As a result, teachers could participate in "video networks" where, as part of conversations about teaching, they share video excerpts from their classrooms. Many teachers already participate in listservs and visit chatrooms related to teaching (Barnett, 2002). The opportunity to respond to a question or issue with video provides interesting opportunities. In fact, it is possible that linking one's comments to classroom video would substantially change the nature of on-line communication among teachers.

The Inquiry Learning Forum (Barab et al., 2001; Barab, Barnett & Squire, 2002) is currently investigating how to create and maintain such a virtual community of novice and veteran teachers. Participants can choose to post video from their own classrooms on the network, along with background materials and commentary on the lesson. Members can then "visit" each other's classrooms by accessing these materials. The Inquiry Learning Forum also supports additional forms of collaboration among participants including a "lounge" for discussing inquiry-related issues and a "collaboratory" for joint lesson-planning.

TOWARD THE FUTURE

While a focus on the affordances of video is an important step toward making effective use of video in teacher education, many questions remain. First, in the previous section, I described several programs that take advantage of the affordances of video. Yet it is not clear how a teacher, administrator, or teacher educator would go about choosing among these programs or the many others that are available. Practical issues such as time and technology constraints certainly play a role, but in addition, various dimensions of video-based programs may also be useful to consider.

For example, one dimension concerns whether the video that is viewed is from the participants' own classroom or from a library of video excerpts provided by a given program. Both approaches have value. Analyzing one's own teaching takes particular advantage of the permanence of video, allowing a teacher to view a lesson from his or her own classroom from the perspective of an observer. This can provide important opportunities to learn more about the ways in which one teaches and about the learning of one's own students. (e.g. What kinds of questions do I generally ask in class? What do my students understand about fractions?) Yet at the same time, viewing oneself on video, particularly with peers, can be a disconcerting experience. Teachers may feel uncomfortable when asked to explain their actions and may interpret questions that arise as criticisms of their teaching. Viewing video exclusively from unknown teachers' classrooms may provide a safer environment in which to explore teaching and learning. In fact, such an approach can be particularly useful in order to gain a vision of what is possible and of practices that differ from one's own. Still, unless sufficient contextual information is provided, the nature of the analysis that takes place may be limited.

A second dimension to consider has to do with the structure provided by a given program. Earlier I discussed the idea that different programs can provide varying degrees of structure for the user. Here I want to emphasize that the *nature* of the structure also varies. For example, while some programs provide a well-defined task for the user, others allow the user to identify the task to be completed. In addition, one program may guide the user to view video excerpts in a particular order. In contrast, a second may offer unlimited access to all of video. More or less structure can also be provided in terms of the user's ability to manipulate the video provided; a program may or may not provide tools that the user can use to edit the video.

There is no single right answer as to what kinds and amount of structure are best. For instance, an argument could be made that greater structure in terms of task selection is likely to be useful for novice teachers. Determining one's own focus for investigation might be better suited to experienced teachers, particularly those who have already acquired reflective capabilities. But counter-arguments are possible. A well-structured task might be required in order to prompt experienced teachers to view teaching and learning in new ways. Similar arguments, both pro and con, can be made concerning the amount of video access and editing capabilities provided by a given program.

Questions and challenges also remain for researchers. First as stated earlier, more empirical research is needed to examine teacher learning in the context of video-based teacher education and professional development. In particular, efforts should be made to characterize both *what* teachers learn as they engage with video and *how* this learning takes place. In addition, researchers should consider combining their efforts in order to create a video archive – a shared database of classroom video, that would be available to teachers, teacher educators, as well as researchers. Such a database could not only document different teaching styles and contexts, but could also record the different kinds of analyses that teachers produce about classroom video. Along the same lines, researchers should work towards the creation of new analytic tools designed specifically to support teachers in explorations of video. Such tools could do much to put the affordances of video in the hands of teachers.

Video has achieved a valued position in teacher education. Ever since its introduction in the early 1960s, video was seen as an exciting innovation with great potential. Across the years a number of different programs incorporating video have been popular. In general, these programs reflected whatever vision of teaching and teacher education was accepted at the time. Moreover, they were designed to do this. Thus, rather than exploit the particular capabilities of video, video was seen as a context through which researchers and teacher educators could embed different activities. In contrast, in this chapter I argue that we must consider the unique affordances that video has to offer teacher education. Video preserves classroom practice in a rich context, it can be catalogued and combined with other data in formats that allow powerful investigations of teaching and learning, and it invites teachers to develop expertise in new kinds of practices. As video technology continues to improve and expand, we must explore new ways of using this technology that take into account the affordances of this valuable medium.

NOTES

1. Many systems today are described using the term *multimedia* instead of *hypermedia*. Technically multimedia simply refers to a system in which multiple media are present. In contrast, in a hypermedia program the elements are linked together.
2. A similar argument can be made with respect to live classroom observations in that the experience of any particular observer provides a biased view of a classroom. Here, however, I simply wish to emphasize that a videotape of a classroom should not necessarily be viewed as an objective record of what took place in the classroom.

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REFERENCES

Achinstein, B., & Meyer, T. (1997, April). The uneasy marriage between friendship and critique: Dilemmas of fostering critical friendship in a novice teacher learning community. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Barab, S. A., Barnett, M. G., & Squire, K. (2002). Developing an empirical account of a community of practice: Characterizing the essential tensions. *Journal of The Learning Sciences, 11*(4), 489–542.

Barab, S., MaKinster, J. G., Moore, J., Cunningham, D., & the ILF Design Team (2001). Designing and building an online community: The struggle to support sociability in the Inquiry Learning Forum. *Educational Technology Research and Development, 49*(4), 71–96.

Barnett, M. (2002, April). Issues and trends concerning electronic networking technologies for teacher professional development: A critical review of the literature. Paper presented at the annual meeting of the American Educational Research Association, New Orleans.

Barnett, C., Goldenstein, D., & Jackson, B. (Eds) (1994). *Mathematics teaching cases; Fractions, decimals, ratios, & percents: Hard to teach and hard to learn*? Portsmouth, NH: Heinemann.

Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher, 15*(7), 5–13.

Berliner, D. C. (1994). Expertise: The wonder of exemplary performances. In: J. M. Mangier & C. C. Block (Eds), *Creating Powerful Thinking in Teachers and Students: Diverse Perspectives* (pp. 161–186). Fort Worth, TX: Holt, Reinhart, & Winston.

Borg, W. R. (1972). The minicourse as a vehicle for changing teacher behavior: A three year follow-up. *Journal of Educational Psychology, 63*(6), 572–579.

Bowers, J. S. (under review). Designing multimedia cases for prospective mathematics teachers.

Bowers, J. S. & Doerr, H. M. (2001, April). Asessing the effectiveness of multimedia case studies: New questions and new answers. Paper presented at the annual meeting of the American Educational Research Association, Seattle.

Copeland, W. D., Birmingham, C., DeMeulle, L., D'Emidio-Caston, M., & Natal, D. (1994). Making meaning in classrooms: An investigation of cognitive processes in aspiring teachers, experienced teachers, and their peers. *American Educational Research Journal, 31*(1), 166–196.

Copeland, W. D., & Decker, D. L. (1996). Video cases and the development of meaning making in preservice teachers. *Teaching and Teacher Education, 12*(5), 467–481.

Cruickshank, D. R., & Metcalf, K. K. (1990). Training within teacher preparation. In: W. R. Houston (Ed.), *Handbook of Research on Teacher Education* (pp. 469–497).

DiMattia, C. (2002). VideoPapers. *Hands On! 25*(2), 12–15. Cambridge, MA: TERC.

Flanders, N. A. (1970). *Analyzing teacher behavior*. Reading, MA: Addison-Wesley.

Frederiksen, J. R. (1992, April). Learning to "see": Scoring video portfolios. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Frederiksen, J. R., Sipusic, M., Sherin, M. G., & Wolfe, E. (1998). Video portfolio assessment: Creating a framework for viewing the functions of teaching. *Educational Assessment, 5*(4), 225–297.

Fuller, F. F., & Manning, B. A. (1973). Self-confrontation reviewed: A conceptualization for video playback in teacher education. *Review of Educational Research, 43*(4), 469–528.

Gamoran, M. (1995, April). Teachers' content knowledge viewed across contexts. Paper presented at the annual meeting of the American Educational Research Association, San Francisco.

Goldman, E., & Barron, L. (1990). Using Hypermedia to improve the preparation of elementary teachers. *Journal of Teacher Education, 41*(3), 21–31.

Goldman-Segall, R. (1998). *Points of viewing children's thinking: A digital ethnographer's journey*. Mahwah, NJ: Erlbaum.

Hatfield, M. M., & Bitter, G. G. (1994). A multimedia approach to the professional development of teachers: A virtual classroom. In: D. B. Aichele (Ed.), *NCTM 1994 Yearbook: Professional Development for Teachers of Mathematics* (pp. 102–115). Reston, VA: National Council of Teachers of Mathematics.

Krajcik, J. S., & Soloway, E. (1996). The Casebook of Project Practices: An example of an interactive multimedia system for professional development. *Journal of Computers in Mathematics and Science Teaching, 15*.

Lampert, M. (1985). How do teachers manage to teach? Perspectives on problems in practice. *Harvard Educational Review, 55*(2), 178–194.

Lampert, M. (2000, April). Issues in the representation of teaching practice: Difficulties and opportunities in multimedia archives. Paper presented at the annual meetings of the American Educational Research Association, New Orleans, LA.

Lampert, M. (2001). *Teaching problems and the problems of teaching*. New Haven, CT: Yale University Press.

Lampert, M., & Ball, D. L. (1990). *Using hypermedia technology to support a new pedagogy of teacher education*. Issue Paper 90–5. East Lansing, MI: Michigan State University, National Center for Research on Teacher Education, 1990.

Lampert, M., & Ball, D. L. (1998). *Teaching, multimedia, and mathematics*. New York: Teachers College Press.

Lampert, M., Heaton, R., & Ball, D. L. (1994). Using technology to support a new pedagogy of mathematics teacher education. *Journal of Special Education Technology, 12*(3), 276–289.

Latour, B. (1990). Drawing things together. In: M. Lynch & S. Woolgar (Eds), *Representation in Scientific Practice* (pp. 19–68). Cambridge, MA: MIT Press.

Leinhardt, G., & Greeno, J. G. (1986). The cognitive skill of teaching. *Journal of Educational Psychology, 78*, 75–95.

Levis, D. S. (1987). Microteaching: Feedback. In: M. J. Dunkin, (Ed.), *The International Encyclopedia of Teaching and Teacher Education* (pp. 722–726). Oxford: Pergamon.

Lewis, C. (2000, April). Lesson study: The core of Japanese professional development. Paper presented at the annual meeting of the American Education Research Association, New Orleans, LA.

Little, J. W. (1993). Teachers' professional development in a climate of educational reform. *Educational Evaluation and Policy Analysis, 15*, 129–151.

McIntyre, D. J., Byrd, D. M., & Foxx, S. M. (1996). Field and laboratory experiences. In: J. Sikula (Ed.), *Handbook of Research on Teacher Education* (pp. 171–193). New York: Simon & Schuster.

Merseth, K. K., & Lacey, C. A. (1993). Weaving stronger fabric: The pedagogical promise of hypermedia and case methods in teacher education. *Teacher and Teacher Education, 9*(3), 283–299.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA.

Nemirovsky, R., Lara-Meloy, T., DiMattia, C., & Ribeiro, B. T. (under review). *Talking about teaching episodes: Discourses and multimodality.*

Olivero, J. L. (1965). *The use of video recordings in teacher education.* Stanford University. (ERIC Document Reproduction Service No. ED 011 074).

Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29*(1), 4–15.

Richardson, V., & Anders, P. (1994). The study of teacher change. In: V. Richardson (Ed.), *Teacher Change and the Practice of Staff Development: A Case in Reading Instruction* (pp. 159–180). New York: Teachers College Press.

Rowley, J. B., & Hart, P. M. (1993). Catching and releasing expert teacher thought: The effects of using videotaped presentations of expert teacher knowledge to promote preservice teacher thinking. In: M. O'Hair & S. Odell (Eds), *Diversity and Teaching* (pp. 122–137). Ft. Worth: Harcourt Brace Jovanovich.

Sherin, M. G. (1996). *The nature and dynamics of teachers' content knowledge.* Unpublished doctoral dissertation, University of California, Berkeley.

Sherin, M. G. (1998). Developing teachers' ability to identify student conceptions during instruction. In: S. B. Berenson, K. R. Dawkins, M. Blanton, W. N. Coulombe, J. Kolb, K. Norwood & L. Stiff (Eds), *Proceedings of the Twentieth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education.

Sherin, M. G. (2001). Developing a professional vision of classroom events. In: T. Wood, B. S. Nelson & J. Warfield (Eds), *Beyond Classical Pedagogy: Teaching Elementary School Mathematics* (pp. 75–93). Hillsdale, NJ: Erlbaum.

Sherin, M. G. (2002). When teaching becomes learning. *Cognition and Instruction, 20*(2), 119–150.

Sherin, M. G. (2003). Using video clubs to support conversations among teachers and researchers. *Action in Teacher Education, 4*, 33–45.

Sherin, M. G., & Han, S. (in press). Teacher learning in the context of a video club. *Teacher and Teacher Education.*

Sherin, M. G., & van Es, E. A. (2002). Using video to support teachers' ability to interpret classroom interactions. *Proceedings of the Thirteenth Annual Meeting of the Society for Information Technology and Teacher Education* (pp. 2532–2536). Norfolk, VA: Association for the Advancement of Computing in Education.

Shrader, G. (2000). *Design research for the living curriculum: The design of case-based performances support for teacher learning.* Unpublished doctoral dissertation, Northwestern University, Evanston, IL.

Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*, 1–22.

Shulman, J. H. (1992). *Case methods in teacher education.* New York: Teachers College Press.

Shulman, J. H. (1997). *Teaching cases: New approaches to teacher education and staff development.* San Francisco: Far West Laboratory.

Shulman, J. H., & Colbert, J. A. (1987). *The mentor teacher casebook.* San Francisco: Far West Laboratory.

Silverman, R., Welty, W., & Lyon, S. (1992). *Case studies for teacher problem solving.* New York: McGraw Hill.

Thomas, G., Wineburg, S., Grossman, P., Oddmund, M., & Woolworth, S. (1998). In the company of colleagues: An interim report on the development of a community of teacher learners. *Teaching and Teacher Education, 14*(1), 21–32.

Tochon, F. V. (1999). *Video study groups for education, professional development and change.* Madison, WI: Atwood Publishing.

van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 10*(4), 571–596.

Willis, J. W., & Mehlinger, H. D. (1996) Information technology and teacher education. In: J. Sikula (Ed.), *Handbook of Research on Teacher Education* (pp. 978–1029). New York: Simon & Schuster.

Woolman, L. (1969). *The effect of video-taped single concept demonstrations in an in-service program for improving instruction.* Houston, TX: University of Houston, College of Education.

Wragg, E. C. (1987). Lesson analysis. In: M. J. Dunkin (Ed.), *The International Encyclopedia of Teaching and Education* (pp. 706–715). Oxford: Pergamon.