Journal of Teacher Education

http://jte.sagepub.com

Selecting Video Clips to Promote Mathematics Teachers' Discussion of Student Thinking

Miriam Gamoran Sherin, Katherine A. Linsenmeier and Elizabeth A. van Es

Journal of Teacher Education 2009; 60; 213
DOI: 10.1177/0022487109336967

The online version of this article can be found at:
http://jte.sagepub.com/cgi/content/abstract/60/3/213

Published by:
SAGE
http://www.sagepublications.com

On behalf of:
AACTE
American Association of Colleges for Teacher Education (AACTE)

Journal of Teacher Education
Volume 60 Number 3
May/June 2009 213-230

10.1177/0022487109336967
http://jte.sagepub.com
hosted at
http://online.sagepub.com

Selecting Video Clips to Promote Mathematics Teachers' Discussion of Student Thinking

Miriam Gamoran Sherin
Katherine A. Linsenmeier
Northwestern University
Elizabeth A. van Es
University of California, Irvine

This study explores the use of video clips from teachers' own classrooms as a resource for investigating student mathematical thinking. Three dimensions for characterizing video clips of student mathematical thinking are introduced: the extent to which a clip provides *windows* into student thinking, the *depth* of thinking shown, and the *clarity* of the thinking. Twenty-six video clips were rated as being low, medium, or high on each dimension. Corresponding teacher discussions of each video were then examined to identify the ways in which clip dimensions served as catalysts for more and less productive teacher conversations of student mathematical thinking. Findings include first, that, under certain circumstances, both low- and high-depth clips lead to productive discussions. Second, high-depth clips in which student thinking is sustained only briefly do not typically lead to productive discussions. Third, in cases where windows and depth are both high, clips that are either low or high in clarity resulted in productive conversations of student thinking on the part of teachers.

Keywords: *teacher learning; video technology; mathematics education*

Like many teacher educators, we have used video with teachers in a variety of contexts, from methods classes to invited workshops to action research groups. Moreover, the videos have come from a variety of sources, including the teachers' own classrooms, our prior research, and published materials. In some cases, we found that we could count on certain video excerpts to promote substantive discussion among participants time and time again. In other cases, however, excerpts that we thought of as stimulating did not promote the kind of teacher discourse we envisioned. In discussions with each other and with other educators about these experiences, we found ourselves asking, "What makes a video clip interesting?" In particular, we wanted to understand what features of a video clip make it a useful resource for having mathematics teachers examine student mathematical thinking.

To investigate this issue, we draw on our work with teachers in video clubs in which teachers meet with colleagues to view excerpts of their teaching (Sherin & Han, 2004; van Es & Sherin, 2008). Certainly, teachers' discussions in a video club are shaped by a myriad of factors: the teachers' relationships with each other (van Es, 2009), the role of the facilitator (LeFevre, 2004), the school and district context (Gamoran et al., 2003), and more. Here, we examine specifically the nature of the video clips viewed and their influence on the conversations that take place.

In brief, we find that we can characterize a range of video clips of student mathematical thinking using three criteria: (a) the extent to which a video clip provides *windows* into

Authors' Note: An earlier version of this article was presented at the annual meeting of the American Educational Research Association in April 2006. This research is supported by the National Science Foundation under Grant No. REC-0133900. The opinions expressed are those of the authors and do not necessarily reflect the views of the supporting agency. The authors wish to thank Andrew Brantlinger and Adam Colestock for their research assistance and Hilda Borko and the anonymous reviewers for their thoughtful comments on this research.

student thinking, (b) the *depth* of student mathematical thinking shown in the video, and (c) the *clarity* of the student thinking shown in the video. Furthermore, rather than claim that a particular level of windows, depth, and clarity is required for productive discussions of student thinking, we identify key relationships between these three criteria that we believe influence teachers' discussions in important ways.

A Situative Perspective on Teacher Learning

Our research draws on a situative view of learning that emphasizes that learning is a social process that takes place as individuals participate in a community (Greeno, Collins, & Resnick, 1996). Furthermore, the activities, discourses, and tools used by the community are understood to be central influences on the learning that takes place (Lave & Wenger, 1991). In particular, the use of tools and artifacts by community members contributes to the development of shared goals and understandings (Engestrom, 1999).

The situative perspective offers important implications for the design of teacher professional development. For example, close attention should be paid to how teachers are organized for learning and to the resources that are used in such contexts (Gamoran et al., 2003; Horn, 2005). Putnam and Borko (2000) argue in particular that the situative perspective highlights the need to ground teacher learning in the practices of teaching. Like others, they recommend using artifacts of practice such as curriculum materials, student work, and classroom video to situate professional development in the context of teachers' work (Ball & Cohen, 1999; Kazemi & Franke, 2004; Nikula, Goldsmith, Blasi, & Seago, 2006; Smith, 2002). In our research, we rely on the use of video as a way for teachers to explore issues of teaching and learning. Moreover, we do so in the context of video clubs to position the activity of viewing video within a professional community.

Characteristics of Video for Teacher Learning

Video is generally thought to be a valuable medium for exploring teaching and learning because it captures much of the richness of the classroom setting. Furthermore, in contrast to the fast-paced nature of instruction, watching video can provide teachers with the time and space needed to reflect on classroom interactions. In considering how to design video-based artifacts for teacher learning, some researchers discuss the technical quality of the video (Goldman-Segall, 1998; LeFevre, 2004; Roschelle, 2000; Towers, 1998). They emphasize the importance of high sound quality and sufficient lighting and discuss the optimum length of time for a video clip and the benefits of various recording formats.

In other work, researchers focus on the content of the video excerpts—that is, on who and what is shown. Three issues are particularly relevant for the current study. First, there is widespread agreement that teachers will gain more from watching authentic, realistic classrooms than from watching staged interactions (Brophy, 2004; Merseth, 1996). In part, this claim is based on the idea that teachers would recognize staged lessons and not take them seriously as examples of instruction. As a result, developers of video cases often try to ensure that the classrooms shown are representative of the types of classrooms with which the user is familiar (e.g., Seago, 2004). As Brophy (2004) explains:

> ideal videos show teachers with whom viewers can identify implementing a curriculum similar to the one they use or will use, in a classroom similar in appearance and student composition to the classroom in which they teach or will teach. (p. 289)

A second issue concerns the availability of information about the context in which a video excerpt is derived. Some teacher educators find that when background information is not provided, participating teachers ask for it (Webb, Diana, Luft, Brooks, & Brennan, 1997). "What happened just before the clip began?" "How often does Derrick speak up in class?" "Have students done this kind of activity before?" Clearly, understanding the context of a teaching-learning interaction is critical if we want to truly understand what is happening (Lampert & Ball, 1998). The real question, then, is how much information is necessary and in what form. In some programs, a series of video excerpts from a single classroom are provided in an attempt to offer more information about the context than would be possible from a single excerpt (Boaler & Humphries, 2005). In other cases, professional development designers provide supplemental information (video or text-based), such as a commentary from the teacher, background on the students, or detailed lesson plans (Seago, Mumme, & Branca, 2004). At the same time, researchers caution that if teachers know too much about the context, they may favor using that contextual knowledge, rather than evidence from the artifact they are examining, to reach their conclusions (Kagan & Tippins, 1991; Seidel, 1998).

Third, research presents varied perspectives as to whether video excerpts should illustrate exemplary practices or teaching dilemmas (Brophy, 2004; Merseth, 1996; Wang & Hartley, 2003). A number of programs use video

as a context to show "best practices" around a particular teaching domain (Oonk, Goffree, & Verloop, 2004; Rosaen, Degnan, VanStratt, & Zietlow, 2004). The idea is that video can be used to help teachers develop a vision of what is possible, a vision that may often be quite different from the kinds of teaching practices teachers typically have the opportunity to see. In contrast, other researchers suggest that video be used as a context for reflecting on practice. Rather than illustrating model implementations of new teaching techniques, video for the purposes of reflection should portray the problematics of teaching. As Seago (2004) explains, "we found that the most useful video clips were based on situations where there was some element of confusion (either the students' or the teachers') that typically arises in classrooms" (p. 267). This sentiment is echoed by Shulman (1996) in discussing the development of narrative cases; he claims that moments of "failure or surprise" are particularly educative for teachers. Central to this perspective is the idea that video clips should provide something for teachers to puzzle over or speculate about—and that it is through this process of inquiry that teacher learning will likely occur.

Using Video to Examine Student Mathematical Thinking

As stated earlier, our goal is to use video as a vehicle through which teachers explore students' mathematical thinking. The need for teachers to attend closely to student thinking has been emphasized by the National Council of Teachers of Mathematics (NCTM). Specifically, the *Principles and Standards* (NCTM, 2000) states that "teachers need to move beyond a superficial 'right or wrong' analysis of tasks to a focus on how students are thinking about the tasks" (p. 24). Furthermore, teachers need to be able to do this at specific moments in time with respect to specific students' ideas (Ball, 1997).

Learning how to listen to and interpret students' mathematical ideas, however, is not a simple task (Chamberlin, 2005). Cohen (2004) explains that one challenge teachers face is recognizing that students have interesting, substantively rich, mathematical ideas. A second challenge concerns the ability to interpret these ideas. Research has shown that in many cases, U.S. teachers do not have well-organized schema for interpreting student thinking of particular mathematical concepts (Carpenter, Fennema, Peterson, & Carey, 1988; Ma, 1999). Yet teachers can benefit from the opportunity to develop new analytic approaches for analyzing the mathematical ideas that students raise during instruction. Cohen (2004) illustrates both advances in teachers' own understandings of mathematics as a result of examining student mathematical thinking and changes in instruction in ways that provide increased support for student learning.

Three Dimensions of Video Clips of Student Mathematical Thinking

With the previous discussion of video and teacher learning in mind, we now turn to the central question of this article: What features of a video clip make it a useful resource for having mathematics teachers examine student mathematical thinking? To explore this question, we focus our investigation on three dimensions of video excerpts of student mathematical thinking: (a) the extent to which a video clip provides windows into student thinking, (b) the depth of student mathematical thinking shown in the video, and (c) the clarity of the student thinking shown in the video**.** We hypothesize that all three dimensions play a key role in establishing a video clip that promotes teacher discussion of student mathematical thinking. Furthermore, we suggest that different video clips may display different degrees of windows, depth, and clarity of student thinking. In what follows, we discuss the basis for our claims about each criterion. The reader may want to refer to Table 1, which provides detailed information about classifying a video clip across each dimension.

The first criteria concerns the extent to which a video clip provides windows into student thinking—that is, ways of "seeing" what a student is thinking. Lave and Wenger (1991) discuss the importance of access to community practices if one is to learn to participate in such practices. Similarly, we expected that for video to be a means for teachers to explore student mathematical thinking, student thinking would need to be clearly visible in the video. Student thinking is frequently observed through students' verbal explanations and written work. In addition, teachers use nonverbal cues, such as gestures, facial expressions, and hesitation or confidence in answering, when making assessments of student understanding (Goldin-Meadow, 2004; Kagan & Tippins, 1991; Webb et al., 1997). As shown in Table 1, a video excerpt considered to be low on the windows dimension provides little evidence of student thinking from any source. A clip considered to be medium on this dimension provides some evidence of student thinking but with little detail. Finally, a video rated as high in windows provides detailed information from one or more sources (e.g., student drawing on board and student verbal description).

The second criterion refers to the depth of student mathematical thinking—in other words, the extent to which the mathematical ideas that students consider in the video are

Table 1
Criteria for Characterizing Video Clips of Student Mathematical Thinking

Criteria	Key Question	Level		
		Low	Medium	High
Windows into student thinking	Is there evidence of student thinking in the video clip?	Little evidence of student thinking from any source (e.g., very few comments from students)	One or more sources of information exist, but little detail provided (e.g., IRE exchanges dominate[a])	Detailed information from one or more sources (e.g., student narrates and provides written account of solution strategy)
Depth of student thinking[b]	Are students exploring substantive mathematical ideas?	Task is routine for student; calls for memorization or recall on part of student (e.g., student applies known algorithm)	Some sense making applied to routine task (e.g., student questions step in known algorithm)	Student engages in math sense making, works on task at conceptual level (e.g., student devises invented strategy)
Clarity of student thinking	How easy is it to understand the student thinking shown in the video?[c]	Student thinking not transparent (e.g., "What is that student talking about?")	Much of student thinking transparent, though some ideas may be unclear (e.g., "I think I understand, but what did she mean by 'straight?'"	Student thinking transparent; viewer sense making not called for or single interpretation obvious (e.g., "She gives a very clear explanation.")

a. IRE is a discourse pattern in which the teacher asks a question (Initiation), followed by the student providing a brief response (Response), followed by an evaluative statement by the teacher (Evaluation) (Mehan, 1979).
b. The depth rating for a video clip is determined by the highest depth demonstrated by any students in the video. For example, if one student in a video clip completes a problem using a known routine (low depth) and another student explains an innovative strategy (high depth), the clip is rated as high in depth.
c. The clarity rating for a video clip is determined by the lowest clarity demonstrated by any students in the video. For example, a video clip is rated as low in clarity if some of the students' thinking remains unclear, even if other ideas are more easily understood.

substantive in nature. Several research studies demonstrate that as student responses move beyond a focus on correctness and rote use of algorithms, teachers begin to develop a deeper appreciation for the complexity of student mathematical thinking (Schifter, 1998; Smith, 2000). Therefore, we hypothesized that video clips illustrating substantive student thinking would most effectively promote teacher learning. A video clip considered "low depth" is one in which students complete a task that is routine for them. In a "medium depth" clip, students continue to work primarily on tasks that are routine for them, but some reasoning is evident. In contrast, a "high depth" clip is one in which students engage in mathematical reasoning and problem solving. Note that a judgment of depth is a judgment not of the potential cognitive demands of a mathematical task itself but rather of students' engagement with the task (Stein, Grover, & Henningsen, 1996).[1]

Third, we propose that video clips can also be categorized according to the clarity of student thinking portrayed, whether a student's idea is transparent or requires some work on the part of the viewer to understand. In line with Seago (2004) and others, we believed that videos considered low in clarity, in which one wonders about a student's statement or how a student arrived at a particular answer, would serve as particularly valuable catalysts for teacher examination of student mathematical thinking. Such "low clarity" clips often illustrate students using novel strategies, making nonroutine errors, or expressing confusion about a mathematical idea. In contrast, clips that are high in clarity may be rated as such because a method is easily interpreted, because a student articulates his or her thinking clearly, or because the teacher in the video clip explains the student's idea. Clips considered medium in clarity were those in which much of the students' thinking is transparent to the viewer, though some ideas may remain unclear.

Research Design

The context for this article is a video club in which a group of seven teachers met over the course of one school year to watch and discuss video excerpts from their mathematics lessons. The teachers taught either fourth or fifth grade and had between 1 and 19 years of prior teaching experience. All seven teachers taught at the same urban elementary school outside a large Midwestern city. The majority of students at the school were African American, and approximately 60% of students

received free or reduced lunch. The video club was initiated as part of a university-district partnership, and these seven teachers were selected by their principal to participate.

The video club met once or twice a month after school for a total of 10 meetings. Each meeting lasted approximately 1 hour. Prior to every meeting, a researcher would videotape one or two teachers' classrooms and select short clips from those classrooms to show at the meeting. A researcher would also prepare a transcript of the excerpts for the upcoming meeting. In all, video from each teacher was viewed two or three times.

Each video club meeting generally followed the same format. A researcher, who also served as a facilitator for the video club meetings, would introduce the video clip.[2] In addition, the teacher whose classroom was portrayed in the video clip might provide background information. The facilitator typically used two kinds of prompts in the meetings. She often started with general questions such as "What did you notice?" and then moved into more specific prompts related to student mathematical thinking, such as "So what do you think Evan understands about fractions?" Much of the discussion that followed was based on comments raised by the teachers, though the facilitator did, on several occasions, refer the teachers back to the video clip when discussions moved to other topics.[3]

Selecting Video Clips

As stated above, in this study, researchers took responsibility for choosing the video clips that would be shown at the meetings. The selection of video clips was not explicitly guided by the features discussed in Table 1, though the researchers did have several face-to-face conversations and e-mail exchanges about how to select "good" clips where "something interesting [was] happening."

Three researchers took part in the selection process. In general, one researcher would videotape in a teacher's classroom and propose a few short interactions as potential video clips. These suggestions would then be reviewed with one or both of the other researchers. The researcher who would facilitate at the upcoming video club would make the final selection of clips to be shown at the meeting. This researcher would also prepare specific prompts to use with the teachers in the video club. Finally, the clips and prompts were discussed with members of the research team prior to the upcoming video club meeting.

Choosing video excerpts for the teachers to view in the video club meetings was challenging for several reasons. First, we were committed to showing video excerpts from all participants' classrooms, yet "student thinking" looked quite different across the teachers' instruction. In particular, the opportunities for students to share their ideas in whole-class discussions or with other students in small groups varied greatly.

Second, we had limited time and resources available to videotape in the participants' classrooms. Unlike some professional development programs that are able to record many hours of classroom interaction to identify a relatively short clip to use with teachers (Brophy, 2004), we generally needed to select an excerpt to show in the meeting by drawing from only one or two lessons. This demand was magnified by the fact that the video club was structured so that teachers watched video of their own (and their colleagues') classrooms from recent weeks in the current school year. Thus, rather than develop a comprehensive series of videos well before it was implemented, we needed to complete the process of selecting—and having teachers view—video clips in a very short time span. Moreover, in doing so, we could not capitalize on the benefit of piloting clips to see how teachers might respond.

Data Sources

Two sources of data are used in this study. The first is the video clips that were selected for use in the meetings. In all, 30 video clips were chosen. Each of these clips was transcribed. Of the 30, three were not shown in the video club meetings because of time constraints, and they are not included in our analysis here. In addition, one clip was selected for the video club because the teacher in the clip, rather than a student, made an interesting comment about mathematics. Because that clip was not intended to portray students' mathematical thinking, we do not consider it in this study. The remaining 26 clips, lasting an average of 5 minutes each, illustrate a range of mathematical topics and draw from varied participant structures in the classrooms (Table 2).

The second source of data consists of the discussions that the teachers had in the video club meetings, following the viewing of each video clip. All 10 meetings were videotaped and transcribed.

Analysis

There were three main phases of analysis. The purpose of the first phase was to rate each video clip as low, medium, or high on our selected criteria. Two researchers independently rated all clips. Interrater reliability on windows was 96%, on depth was 84%, and on clarity was 88%. In addition, we used the coding of the clips to determine if the three selected dimensions allowed us to

Table 2
Video Clips Shown in the Mapleton Video Club

Clip No.	Teacher	Mathematical Topic	Participant Structure
1a	Wanda	Sum of angles of a polygon	Whole class discussion
1b	Yvette	Ratios and scale factors	Whole class and student-to-student
2a	Frances	Comparing fractions	Whole class discussion
2b	Frances	Equivalent decimals and fractions	Whole class discussion
2c	Daniel	Equivalent decimals and fractions	Student-to-student
3a	Drew	Adding decimals	Student(s) presenting solution at board
3b	Drew	Writing decimals (from spoken values)	Student(s) presenting solution at board
4a	Yvette	Multiplying numbers up to 10	Student-to-student
4b	Daniel	Multiplying by multiples of 10	Student-to-student
5a	Wanda	Positive and negative numbers	Whole class discussion
6a	Linda	Multidigit multiplication	Whole class and individual student work
6b	Elena	Division algorithm	Student(s) presenting solution at board
7a	Drew	Equivalent fractions	Student(s) presenting solution at board
7b	Drew	Equivalent fractions	Whole class discussion
8a	Frances	Multiplying fractions	Small group with teacher
8b	Frances	Multiplying improper fractions	Student(s) presenting solution at board
8c	Drew	Ratios and scale factors	Whole class discussion
8d	Daniel	Ratios and scale factors	Whole class discussion
8e	Daniel	Ratios and scale factors	Whole class discussion
9a	Frances	Area and perimeter	Whole class discussion
9b	Frances	Area and perimeter	Individual student with teacher
9c	Linda	Equivalent fractions and percentages	Whole class discussion
10a	Wanda	Combinations	Student-to-student
10b	Yvette	Equivalent fractions, decimals, & percentages	Whole class discussion
10c	Yvette	Equivalent fractions, decimals, and percentages	Whole class discussion
10d	Daniel	Multiplying decimals	Student(s) presenting solution at board

Note: The clip number identifies the video club meeting in which the video clip was viewed, as well as its order relative to other clips viewed in the meeting. For example, in the second meeting, three clips were viewed; we refer to them as Clips 2a, 2b, and 2c.

distinguish between the clips. That is, we wanted to ascertain the extent to which the video clips exhibited a variety of combinations of windows, depth, and clarity.

Coding the Video Club Discussions

Next, to ascertain whether certain types of video clips led to productive discussions of student mathematical thinking, we needed to have a way to determine whether a discussion was "productive" or not. Therefore, the goal of the second phase of analysis was to characterize the nature of the teachers' discussions of each clip across the 10 video club meetings. Based on a review of the literature on professional development, we selected three criteria to use to assess the teachers' video club discussions. In addition, we identified three different levels at which each criteria might be evident in the teachers' discussions (Table 3).

The first criterion concerns whether the teachers focus on understanding student thinking. Specifically, we wanted to determine whether the teachers treat students' ideas as objects of inquiry that deserve "careful consideration" (Cohen, 2004, p. xiv) and are worth trying to understand. A wealth of research supports the idea that professional development is most effective when teachers are engaged in sustained inquiry (Hiebert, Morris, Berk, & Jansen, 2007; Putnam & Borko, 2000; Wilson & Berne, 1999). In fact, Ball and Cohen (1999) argue that "a stance of inquiry" is "central to the role of the teacher" (p. 9). Of issue here is whether teachers bring this inquiry stance to their investigation of student mathematical thinking. A discussion is rated low on this dimension if students' ideas are not identified as objects of inquiry and medium if some interest in students' ideas is apparent but there is little attempt to figure out the meaning of students' thinking. In contrast, a discussion rated as high on this dimension would involve a sustained attempt to make sense of students' ideas (Table 3).

Second, we consider the extent to which the teachers explore substantive mathematical ideas. The wealth of research on "pedagogical content knowledge" (Shulman, 1986) and more recently on "knowledge of content and students" (Ball, Thames, & Phelps, 2008) makes clear that teachers need to engage with students' ideas in ways

Table 3
Criteria for Characterizing Teacher Discussion of Student Mathematical Thinking

Criteria	Key Question	Level		
		Low	Medium	High
Focus on student thinking	Is student thinking an object of inquiry for teachers?	Student ideas not identified as objects of inquiry; restatements of student ideas offered	Student ideas identified as objects of inquiry, but little attempt to figure out meaning of student comment or method	Student ideas identified as objects of inquiry and sustained attempt made to make sense of student thinking
Mathematical substance of discussion	Do teachers explore substantive mathematical ideas in the student thinking?	Discussion focused primarily on superficial aspects of student mathematical thinking (e.g., noting the use of proper mathematical notation)	Discussion of student thinking contains a mixture of superficial and substantive mathematical ideas	Discussion of student thinking primarily focused on substantive mathematical ideas (e.g., the reasons why an invented method works in only some cases)
Joint sense making	Do teachers work together to make sense of what is happening in the video?	Discussion consists primarily of isolated and disjointed teacher comments	Teachers occasionally respond to and build on each other's ideas; discussion also consists of disjointed teacher comments	Teachers consistently respond to and build on each other's ideas; teacher comments support joint sense making of events in video

that involve looking deeply into the subject matter under consideration. Furthermore, the expectation is that professional development should provide teachers with opportunities to do so (Hiebert et al., 2007). Yet at the same time, researchers find that teachers in the United States often focus on superficial aspects of mathematics when explaining students' methods or crafting explanations to offer students (Ball, 1991; Ma, 1999; Stein, Baxter, & Leinhardt, 1990). Our focus on the ways in which teachers treat the mathematical content of discussions attempts to distinguish between these approaches. A rating of low represents primarily superficial consideration of mathematical ideas, medium refers to a mix of superficial and substantive mathematical ideas, and high indicates that substantive mathematical ideas are the primary focus of discussion.

The third criterion concerns whether the teachers engage in joint sense-making concerning the interactions shown in the video. This criterion reflects recent claims that professional development should be a collective endeavor in which teachers are encouraged to share their knowledge about teaching and learning with colleagues (Ball & Bass, 2003; Hiebert & Stigler, 2000). In particular, Chamberlin (2005) demonstrates that discussions in which teachers build on one another's ideas promote teacher learning about student mathematical thinking. As shown in Table 3, we rated a discussion as low on this dimension if it consisting primarily of disjointed comments, as medium if a mix of responsive and isolated comments was exhibited, and high in cases where teachers' comments primarily responded to and built on one another's ideas.

With these criteria in mind, one researcher coded all 26 discussions and a second researcher coded a subset of 13 of the discussions. Interrater reliability for understanding student thinking was 92%, for substantive mathematical ideas was 85%, and for joint sense-making was 85%. Finally, we note that no discussions were rated as low on one dimension and as high on another dimension. Instead, all 26 discussions had either low and medium ratings or medium and high ratings across all three dimensions. We therefore assigned an overall rating to each discussion. Those that were coded as low or medium on all three dimensions were considered "less productive" discussions, whereas those coded as medium or high on all three dimensions were referred to as "more productive" discussions.[4]

Comparing Codes of Video Clips and Codes of Corresponding Discussions

With the coding of the video clips and the discussions complete, we now proceeded to the third phase of analysis in which the goal was to compare the coding of the video clips with the coding of the corresponding video club discussions. In doing so, we focused on a subset of four video club meetings. Our reason for doing so is that in related research (van Es & Sherin, 2008), we found

evidence of teacher learning over the course of the video club. In particular, the teachers came to focus more often on student thinking and to more consistently use details from the video to support their claims. To examine the relationship between the video clips and the corresponding discussions, irrespective of this overall trend of learning, we chose to focus our analysis only on video club meetings that comprised both more and less productive discussions. This decision eliminated three video club meetings from analysis, two because they only contained more productive discussions and the third because only one video clip was viewed. In addition, we chose not to analyze the first video club meeting because factors other than the video clip, in particular the establishment of group norms, likely played a significant role in shaping the discussions in that meeting. Of the six remaining meetings, we chose to balance the number of earlier and later meetings. Thus, we selected two early meetings (2 and 4) and two later meetings (8 and 10) as the focus for this phase of analysis.

Across these four meetings, the teachers discussed 14 video clips and had 7 discussions that were coded as more productive and 7 that were coded as less productive. We then systematically looked for patterns in the coding of the clips and of the corresponding video club discussions. In particular, we examined whether specific combinations of ratings of windows, depth, and clarity consistently resulted in either more or less productive discussions.

Results and Discussion

In presenting our results, we first provide an example from the data to give the reader a sense of how we applied the selected criteria to code the video clips and the video club discussions. Next, we describe the results of coding the 26 video clips. Finally, we consider the relationship between the video clips and the corresponding discussions of those clips. In doing so, we discuss three findings concerning the ways in which features of the video clips influenced the teachers' discussions of student mathematical thinking.

Exploring Student Ideas About Ratios

The following example comes from the eighth video club meeting. In this meeting, five different video clips were viewed from three teachers' classrooms. Two video clips were shown from one of Ms. Lempke's lessons: one clip came from Mr. Evan's class and the final two episodes came from a lesson in Mr. Novak's class.[5]

In the lesson from Mr. Novak's class, students were exploring ratio and scale factors. Mr. Novak had written the following problem on the board at the front of the room. "If 1 inch represents 50 miles, then ½ inch represents how many miles?" Students first worked on the problem individually and then discussed their answers as a whole class. The 3.5-minute video clip begins with Mr. Novak inviting Matthew to share his solution:

Matthew: Seventy-five . . .
Mr. Novak: Talk us through your thinking here. Tell us the whole problem, and what your thinking was.
Matthew: I knew 50 and 100, a hundred was, um . . .
Mr. Novak: What are we looking for Matthew? What are we trying to figure out?
Matthew: Like, what's one half more. Like what a half equals.
Mr. Novak: And what do we know already?
Matthew: That one inch is 50 miles.
Mr. Novak: So 1 inch is 50. Is a half bigger or smaller than 1? Is having half a pizza bigger or smaller than having a whole one pizza?
Matthew: Smaller. So if 1 is equal to 50 . . .
Mr. Novak: Listen to you.
Matthew: I know 50 equals 1 inch. So I just did . . . I . . .
Mr. Novak: We know 1 is 50. What do you know about half?
Matthew: I just put 50 and then, till 100, and that's 50, 60, 70, 80, 90, and 100. I just did half of 50, and it would be like 70 and 80, and I just added 5 so it would be equal in the middle.
Mr. Novak: I'm hearing a lot of different strategies in there Matthew.

We coded this particular classroom episode as being high in windows, high in depth, and low in clarity. The video clip is considered high in windows because detailed information about Matthew's thinking is provided. For example, Matthew demonstrates that he understands the original premise of the problem, by repeating that "1 inch is 50 miles," and that he recognizes a half is smaller than a whole. In addition, Matthew not only states that the answer is 75, he also explains the process he used to arrive at this answer. This video clip is high in mathematical depth because Matthew is reasoning his way to an answer and not simply following a prescribed set of steps. Despite the abundant windows into Matthew's thinking, this video clip remains low in clarity. It is not clear why Matthew so persistently gives the wrong answer, even though he understands that one half is less than 1.

The Video Club Discussion

In the video club meeting, the teachers discuss Mr. Novak's exchange with Matthew for 12 minutes.

Initially, Elena suggests that students are often confused if they have to find one half of a number when units are involved. Mr. Novak agrees. Note that we refer to Mr. Novak by his first name, Daniel, in the excerpts below:

Elena: That seems to be so confusing for a lot of the kids, the half, when we [add units] . . .
Daniel: But they have no problem with, like, a half of something.
Elena: Right, but as soon as you get into the [units], it's . . .
Daniel: In the inch, in the miles, and it's like . . . the frame of reference . . .

The facilitator then asks the teachers, "What did Matthew think the question was asking?" In the conversation that follows, the teachers look in-depth at Matthew's comments. In particular, Linda proposes that Matthew misunderstood the problem and was trying to find "one plus one half more."

Daniel: He wanted to double the 50 for some reason. He wanted to make it twice as big. I still don't get . . . "60, 70, 80."
Frances: . . . Yeah, he doesn't understand what the question is asking him. That's his first problem. He doesn't really understand the question.
Linda: But if he's thinking, "What is one plus one half more?" then he would have been right going up to 100.
Elena: [Reads from transcript] "What's one half more?"
Daniel: What's one plus one half more?
Linda: 'Cause he started at 50, and then he did 50 more, and he must have done, like a number line thing. And then, he knew that half would be between 50, I mean 70 and 80. He got 75. I thought that was good.

The teachers continue to discuss Linda's proposal, and they also raise additional questions about Matthew's reasoning. For example, Daniel wonders if perhaps Matthew was correcting himself when he stated, "What's one half more. Like what a half equals." Daniel's idea is that Matthew may have realized that "one half more" is not a clear statement, and so he offered the more precise "what a half equals." In considering what Matthew understands about the problem, Frances refers the group to evidence that Matthew understands that 1 inch is 50 miles and that ½ is less than 1. As the discussion proceeds, the teachers focus on the apparent contradiction in Matthew's thinking.

Drew: It's just bugging me that he was wanting to go bigger. You know 1 of something is 50, and ½ is going to be smaller. [But] for some reason, he was wanting to go bigger than the 50.

Specifically, they try to find a reasonable explanation for why Matthew might both have been trying to find ½ of 50 and at the same time expect the answer to be a number greater than 50. In doing so, the teachers discuss the range of problem types involving scale factors and note that in many scaling problems students encounter in class, the resultant value is larger than the starting value. They also discuss issues with language when working with fractions. As Wanda explains:

I think, when you get into a half and a fourth, you get into a language problem because we refer to one half as "a half." "A fourth" instead of one fourth. And so, when they're reading the fraction, they're reading "One, oh, it's a half." "One . . . a half, one and a half." I don't know if that's what's going on here, but I do notice that problem with some of those fractions.

Before the discussion concludes, the teachers wonder if Matthew is having trouble not only with the language of fractions but also with the underlying concept of part-whole relationships:

Linda: A lot of times when I have the younger children who haven't really been exposed to fractions, they'll see one [fourth] plus one third and they'll go "1, 2, 3, 4, 5, 6, 7 . . . 7." So maybe . . . they don't have a full understanding yet of . . . how a fraction's different from the whole.
Wanda: Yeah, I think I agree with that. The fractions . . . they're not understanding fractions as part of something, as part of a whole . . .

Daniel agrees and suggests that although Matthew likely knows what half of 50 is, in this problem he has to coordinate two different part-whole relationships, that of inches to miles as well as miles to miles.

We coded this discussion as high on all three dimensions of understanding student thinking, substantive mathematical ideas, and joint sense making. First, throughout their conversation, the teachers are trying to make sense of Matthew's thinking. Even when the teachers restate Matthew's comments, they do so in an effort to provide evidence for their claims about his reasoning. Matthew's solution of "75" and his thinking about "one half" and "one half more" are clearly objects of inquiry for these teachers.

Second, we claim that the teachers discuss substantive mathematical ideas related to the video clip. In particular, the teachers go beyond merely noting a potential language confusion (i.e., "one half" versus "one half more") to talking about the context in which such language is problematic for

Table 4
Rating of Video Clips by Level per Criteria

	Windows			Depth			Clarity		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
No. of clips	10	3	13	8	4	14	14	0	12
% of clips	38	12	50	31	15	54	54	0	46

students. In doing so, they explore scale factors and the relationship between problems calling for scaling up versus scaling down. In addition, they discuss the nature of Matthew's understanding of fractions and, in particular, that of part-whole relationships.

Third, in their discussion of this video clip, the teachers engage in joint sense making. For example, notice the progression of the comments after the facilitator's initial question of "What did Matthew think the question was asking?" Rather than making isolated comments, each teacher responds to what the previous teacher has said. Daniel begins by saying, "He wanted to double the 50." Frances confirms that Matthew seems confused about what the question is asking. Linda goes on to propose how Matthew might be interpreting the problem. Both Daniel and Elena consider Linda's proposal. In fact, Elena uses Matthew's own words to support Linda's idea. In this way, the teachers worked together to make sense of what they viewed in the video excerpt. Such joint sense making was apparent throughout the teachers' discussion.

Because all three dimensions were coded as high, we gave this discussion an overall rating of "more productive." We perceived the teachers to be engaged in an in-depth discussion of students' mathematical thinking, in which the teachers themselves served as a resource for each other and important mathematical ideas were considered.

Distinguishing Among Video Clips of Student Mathematical Thinking

We now turn to our analysis of the video clips viewed during the 10 video club meetings. Looking across our ratings of the 26 video clips reveals that the clips illustrated student mathematical thinking in a variety of ways. In other words, using the criteria of windows, depth, and clarity did allow us to distinguish between the clips viewed in the video club meetings. Furthermore, in all but three cases of windows and four cases of depth, the selected ratings were either low or high; medium was not often used as a rating (Table 4).

The range among the clips in terms of windows and clarity was not particularly surprising to us. Although we generally looked for clips that had extensive windows into student thinking, we could also recall clips we considered noteworthy precisely because there was a single utterance of interest by a student. Similarly, the range among the clips in terms of clarity was not a surprise to us. We understood this to indicate that we had selected some clips because they illustrated students clearly explaining complex mathematics ideas and other clips because students' ideas were not clear, and we found it of interest to puzzle over what students had said and done. What did surprise us, however, was the range among the depth of the clips we had selected. We had strongly held beliefs that "high depth" was critical for productive conversations among the teachers, and we thought that, to the best of our ability, we had selected excerpts that were as high in depth as possible, given the observations conducted. On closer examination, however, we could see that almost one third of the selected clips involved students engaged in thinking that was, mathematically, rather routine and that did not generally involve mathematical sense making. To be clear, as discussed earlier, student thinking was represented in different ways across the teachers' classrooms, and in taping only one or two lessons, we were limited in the types of activities from which we could choose. One hypothesis then, at this point, was that the teachers' discussions would be differentiated along the lines of the degree of depth of the video clip and that, to some extent, windows and clarity would play a less decisive role.

One other point about our coding of the video clips is worth noting: The coding revealed a range of combinations among the three criteria when we looked across the three dimensions for the 26 clips (Table 5). Thus, it was not the case, for example, that all video clips coded as low in windows were the same video clips that were coded as low in depth. On the contrary, video clips coded as low in windows were found to be either low, medium, or high in terms of depth. We also noted that the most frequent combination of ratings was high windows and

Table 5
Rating of Video Clips Across the Criteria

Clip Coding				
Windows	Depth	Clarity	No. of Clips	% of Clips
Low	Low	Low	2	8
Low	Low	High	3	12
Low	Medium	Low	1	4
Low	Medium	High	2	8
Low	High	Low	1	4
Low	High	High	1	4
Medium	High	Low	2	8
Medium	High	High	1	4
High	Low	Low	2	8
High	Low	High	1	4
High	Medium	Low	1	4
High	High	Low	5	19
High	High	High	4	15

Note: Because of rounding, the percentage total adds up to more than 100%.

Table 6
Comparison of Video Clips and Teacher Discussions

	Clip Coding			
Clip No.	Windows	Depth	Clarity	Discussion Coding
2a	Low	Low	High	Less productive
2b	Low	High	High	Less productive
2c	High	High	High	More productive
4a	High	Low	Low	More productive
4b	Low	Low	Low	Less productive
8a	Low	Medium	Low	Less productive
8b	High	Low	High	Less productive
8c	High	High	High	More productive
8d	High	High	Low	More productive
8e	High	High	Low	More productive
10a	High	Low	Low	More productive
10b	Low	Low	High	Less productive
10c	Low	Medium	High	Less productive
10d	High	High	Low	More productive

high depth; more than one third of clips were rated as high in windows and high in depth.

The Influence of Video Clips on Teachers' Discussions

Here, we present our findings concerning the relationship between the clip dimensions and the discussions of student mathematical thinking that ensued. In particular, three key findings are the focus of the discussion that follows. The reader may want to refer to Table 6, which displays the results of coding the video clips and corresponding video club discussions from Meetings 2, 4, 8, and 10.[6]

Before proceeding, we want to mention one additional point. We found that we had selected three clips that were low in both windows and depth (Clips 2a, 4b, and 10b).[7] We expected clips without much evidence or depth of student thinking to provide little fodder for discussion, and thus, we did not set out to choose clips of this sort. Our selection of such clips, however, provided us with the opportunity to check our assumption. As expected, clips that were low in both windows and depth did consistently lead to less productive discussions of student thinking.

(1) Viewing a Clip That Is High in Depth Does Not Necessarily Ensure That Productive Conversations Will Follow

Video clips that were coded as high in depth did not necessarily lead to productive discussions. On several occasions, our coding provided evidence of less productive discussions that were based on high depth clips. Looking closely at these cases (e.g., Clips 2b and 8a) revealed that, for the most part, such clips contained only short bursts of student sense making. This was in contrast to other clips in which deep mathematical thinking was sustained over a period of time. To our eyes, such moments were quite captivating; as researchers, we found ourselves frequently intrigued by an interesting comment from a student even when it was not pursued in the lesson. This was not the case for the teachers in the video club. On the contrary, fleeting moments of mathematical sense making from students tended to result in less productive discussions.

The video clip. For example, in Clip 2b, the class is converting successive fractions into decimals (e.g., $^1/_2$ = 0.5, $^2/_2$ = 1.0, $^3/_2$ = 1.5, etc.). The teacher is filling in a chart at the overhead while students complete the same chart at their desks. For the most part, the teacher treats this as a pattern recognition activity. For instance, counting by halves is equivalent to counting by fives with a decimal point inserted between the digits. The majority of talk from students involves occasional short responses to the teacher. Consider the following excerpt:

Ms. Lempke: Decimal equivalent for one fourth . . . twenty-five hundredths. Okay, everybody see where I am?

Students: Yes.
Ms. Lempke: Twenty-five hundredths. Okay, now keep in mind that decimals mean hundredths and . . . that a fourth of a dollar is just like having one quarter, just like having one quarter, correct?
Alicia: Mmm, hmm.
Ms. Lempke: So, if I was to say then, what is two-fourths of a hundred? Or two-fourths of a dollar? What would, how many cents would you have? If you had two-fourths of a dollar, how many cents would you have? Liam?
Liam: Fifty.
Ms. Lempke: Fifty cents. Because . . . you'd have two quarters, so that's what you would put in the next box.

During the 6.5 minute clip, students occasionally comment on the use of zeros in decimal numbers. In each case, the student's comment is acknowledged by the teacher but is not explored further. For example, at one point, the teacher asks the class how to "read a dollar fifty as a decimal." Adam responds, "one and fifty hundredths." Daphne then offers "one and five hundred thousandths."

Ms. Lempke: One and five hundred thousandths? How many zeros have we got there? In a dollar fifty, how many zeros have we got?
Daphne: . . . Well I was adding another one.
Ms. Lempke: Oh, you were adding another one. Okay . . . but we're not. All right, who can read the last one?

Later, the class is working with one fifths (1/5 = .20, 2/5 = .40, 3/5 = .60). The teacher has just filled in the chart with 5/5 = 1.0 when Sasha raises her hand:

Sasha: I did that Ms. Lempke, but I didn't put the zero at the end.
Ms. Lempke: Okay, you will fix it now though, [and] put the zero. You got it?

Following Ms. Lempke's response to Sasha, the class continues to complete the chart. "Okay, what would come after the 1.0?" No discussion of Sasha's comment is pursued.

We coded this clip as low in windows and high in depth and clarity. The low windows is due to the fact that student comments are infrequent and brief. At the same time, however, depth was coded as high. Despite the brevity of their comments, these students are considering an important conceptual issue—the use of zero in decimal numbers and the idea that decimal values with different numbers of digits can be equivalent (Behr, Harel, Post, & Lesh, 1992). Furthermore, the students appear to be engaged in sense making. Daphne offers a novel response to the teacher's question about "a dollar fifty," while Sasha asks about the difference between decimal numbers with and without a zero. The clip was coded as high in clarity because the students' comments were clearly stated and could be easily understood.

The video club discussion. The teachers' discussion of this clip was coded as "less productive." Specifically, when the teachers talk about what the students in the video do and do not understand, student thinking is not treated as an object of inquiry. On the contrary, the teachers' statements reflect broad generalizations of students' understanding without looking closely at the meaning of students' comments or questions. "They understood that four quarters was a dollar, and three was 75 cents." "They seemed to know how the chart works." "They don't do as well with the halves."

Furthermore, their comments about the mathematical issues related to the video are not substantive in nature. For example, the teachers discuss the strengths and weaknesses of the worksheet that accompanied the lesson in terms of the how the information on the chart is organized and surface-level differences between the teacher's chart and what students were filling out at their desks. Even when the teachers mention students' comments about the use of zero in decimal numbers, the conceptual basis for these ideas does not come up. Instead, the teachers state, rather briefly, that:

Virginia: Sometimes [math books] put the zero. Sometimes they don't.
Frances: With [decimals] you say it doesn't matter. You could put that zero or you could leave it off.

Finally, this discussion is characterized by primarily isolated comments from the teachers about how they approach the teaching of decimals in their own classes and what they find challenging in doing so. The teachers do not appear to be engaged in working together to build a consensus about the events in the video or the implications for their own instructional purposes.

What we find striking about this discussion is that the teachers do not seem to view the video clip as a resource for exploring student mathematical thinking. At no time do they point to an individual student comment and ask what a student means or express interest in the student's idea. We suspect that the combination of low windows paired with high mathematical depth that is evident only

in short bursts resulted in a video clip that was not a viable resource for the teachers. Lave and Wenger (1991) argue that transparency is a feature not of an artifact itself but of the ways in which the community perceives the artifact. In this case, the short comments that stood out to us in our initial review of the video clip did not appear noteworthy to these teachers.

(2) Viewing Clips That Are Low in Dept Can Lead to Productive Conversations

One of our key assumptions in selecting video clips was that the clips should illustrate rich mathematical thinking on the part of students. Without this, we hypothesized, the corresponding discussions would not contain much mathematical substance. In reviewing the video clips and the resulting discussions, we were surprised to learn that clips that seemed lacking in mathematical depth (e.g., Clips 4a and 10a) at times led to "more productive" discussions. Our analysis revealed that, with certain video clips (particularly those that were high in windows), the teachers treated the mathematics more deeply than had the students in the video.

The video clip. For example, in Clip 4a, two fourth grade students are playing a card game designed to help them practice their multiplication facts. Each student has a stack of specially designed playing cards, in which each card contains a numeral 0 through 10 and the corresponding number of dots. The players draw two of their own cards at a time and state the product of the two numbers. The player with the higher product receives all four cards. Players may challenge each other's answers and use a multiplication chart to check that the answers given are correct.

Despite the fact that the talking in this video clip is limited to brief comments, such as "sixty-four, I guess I win," and some gloating about game performance, the clip contains quite a bit of evidence about what students are thinking. The clip was coded as high in windows largely because of nonverbal clues to students' thought processes. For example, through their gestures, we see students counting on their fingers, tapping the dots on their cards in sequence, and using the multiplication chart to identify answers.

This video clip was coded as low in depth because the students are following a routine set of steps. They are not reasoning through a new way of thinking, nor do they appear to be thinking about why their solution methods work. Finally, the video was coded as low in clarity. Despite the abundance of windows into the students' methods, their thinking remains confusing at the end of the video clip. Students give both correct and incorrect answers, sometimes to the same multiplication problem presented at different times, and there is little about the situation that gives us clues as to why this might be the case. In addition, it is not clear how the students decide when to challenge each other's answers.

The video club discussion. Despite the lack of depth of student thinking portrayed in the video clip, the teachers' discussion is quite rich and was coded overall as "more productive." In fact, even while the clip is still playing, the teachers begin to ask questions about what the students in the video understand and why they might be giving particular answers. "How did he get that [answer]?" "[What] is he looking for . . . ?" In doing so, the teachers make clear that they want to make sense of the responses and actions illustrated by the students in the video.

As the discussion continues, the teachers consider the mathematics in which the students are engaged from a substantive perspective. Specifically, while the students in the video clip appear to be simply practicing their multiplication facts, the teachers' discussion of the clip goes beyond fact practice and focuses on the meaning of multiplication. For example, Wanda notices that a student is using his finger to tap on the cards as he counts:

Wanda: [I noticed] the way he was counting on the card in the later one. . . . He was counting the groups. . . . I think it was three times six.
Daniel: So what was he doing?
Yvette: He was counting it that many times.
Wanda: Which I thought was interesting.
Daniel: When he counted six and then another six, I mean . . .
Frances: Yes, and he was keeping track. You noticed he was counting with one–one, two, three, four, five, six. And then he was keeping track, so he knew he counted six one time, six the second time, six the third time.
Daniel: Well, then, he knows what the meaning of multiplication is.
Wanda: Which is . . . exactly. I mean, that's the base.
Yvette: He just hasn't retained the facts.

In addition to providing evidence of the substantive nature of the teachers' discussion, the above excerpt illustrates that the teachers are engaged in a high degree of joint sense making. Daniel responds directly to Wanda in asking, "So what was he doing?" Furthermore, Yvette, Daniel, and Frances together reconstruct the student's strategy. And finally, Daniel, Wanda, and Yvette all contribute related ideas concerning how the student's strategy

provides insight into what the student understands about multiplication.

In sum, despite the fact that the students in this clip are engaged in a rather mundane mathematical task, the teachers are able to have a productive discussion of student thinking. We believe that this phenomenon may be related to Ma's (1999) notion of teachers' profound understanding of fundamental mathematics. Ma argues that teaching mathematics requires that teachers reason deeply about basic mathematical ideas. Video clips that are low in depth but remain high in windows may offer teachers precisely the opportunity to do so.

(3) The Complexity of Clarity

We initially believed that clips in which students' ideas were unclear would lead to productive discussions. A lack of clarity, it seemed, would prompt teachers to want to understand the ideas presented in the video clip (Seago, 2004). And as we predicted, the teachers did have "more productive" discussions about clips that were high in windows and depth but low in clarity (e.g., Clips 8d, 8e, and 10d)—in other words, clips that contained substantial student thinking to figure out. Contrary to what we predicted, however, teachers also had worthwhile discussions about clips that contained a great deal of well-explained student thinking (i.e., clips that were high in windows, depth, and clarity). In such cases (e.g., Clips 2c and 8c), the fact that a student's explanation was clear did not deter the teachers from viewing the idea as an object of inquiry.

For example, in Clip 8c, a student explains an invented strategy for solving a problem about ratios. In addition to his initial verbal explanation, the student illustrates his work on the board and responds to questions from his teacher. Although it takes quite a bit of prompting from the teacher, the student provides a complete explanation of the thinking behind his method and of the method itself. The clip was therefore coded as high in widows, depth, and clarity.

In discussing this video clip, the teachers express a great deal of interest in the student's novel method. Consider the following excerpt:

Frances: I would have never thought of doing it that way.
Wanda: He was relating it to percents, 50%, 100%. And he eventually set up a ratio. If 15 is the half, you know, how does this change? I'll change this the same way.
Frances: And he worked backwards actually, starting from the whole, and he worked smaller and smaller.
Wanda: Which makes sense.
Linda: . . . And he knew that a fourth was half of a half. And so then he went over to the numbers [in the problem].
Elena: 50, 25 . . .

Although the teachers do not raise questions about the student's strategy, they nevertheless articulate what the student did. Furthermore, they offer explanations and insights into the student's approach in a manner that focuses on substantive aspects of the mathematics involved, specifically the relationship between ratios, percents, and fractions. In addition, both in the excerpt above and the discussion that follows, the teachers build on each other's ideas as they discuss the student's method.

To be clear, although our analysis revealed that high clarity video clips could lead to productive discussions, they do not always do so. In particular, clips that are high in clarity but low in depth (e.g., Clips 2a, 8b, and 10b) do not seem to provide access to sufficient content to lead to the sort of engagement illustrated above.

In summary, our analysis supports the diverse views of clarity represented by prior research. At times it can be helpful for a video clip to pose a problematic issue for teachers to explore (Seago, 2004). In addition, teachers find value in examining detailed student methods that are not necessarily problematic (Rosaen et al., 2004). Although we found that clarity is not a sole determining factor in the quality of a video clip discussion, neither is it the case, however, that the clarity of a clip is irrelevant. Rather, clarity's effect on ensuing discussions appears to depend on a video clip's other characteristics.

Conclusion

A situative perspective on professional development maintains that the tools used to support teacher learning should be closely tied to the practices of teaching (Putnam & Borko, 2000). We believe that video has the potential to serve in such a role, yet little empirical research investigates what kinds of video clips might be useful in a professional development context. To address this issue, we set out to identify characteristics of video clips designed specifically to promote teacher discussion of student mathematical thinking. In doing so, we focused on three criteria: (a) the extent to which a video provides windows into student thinking, (b) the depth of student mathematical thinking shown in the video, and (c) the clarity of the student thinking shown in the video.

Drawing on data from a year-long video club with elementary teachers, we compared the nature of the video clips viewed with the discussions of student thinking that took place. We found that our a priori assumptions about the relationships between the clip dimensions were not always supported by the data. For example, our expectation that high depth was a necessary condition for teachers to have a productive discussion of the corresponding video was not substantiated in two ways. First, video clips that were high in depth did not always lead to productive discussions. Second, some productive discussions were based on video clips that were coded as low in depth. In addition, we predicted that clips that were low in clarity, in which the student thinking portrayed required elaboration and interpretation, would be most productive for teachers. In contrast, we found that both high and low clarity clips could lead to either more or less productive discussions, depending on the level of windows and depth present in the clip.

Our analysis suggests that it is the relationship between the video clip dimensions that is most important in predicting whether a video clip will support in-depth conversations of student thinking on the part of teachers. For example, a clip that is low in both windows and depth provides teachers with little to discuss, regardless of the clip's clarity. If a clip has a high degree of windows (i.e., if there is sufficient information about student ideas), then discussions about that clip are likely to be productive if depth is high and/or clarity is low. In other words, low depth does not "kill" a clip if clarity is also low, meaning that teachers must engage in a fair amount of sense making to understand what occurs in the clip. In addition, if a clip is high in clarity, then to promote a productive video club discussion, it also must be high in depth, thus providing the teachers with something particularly interesting with which to engage.

A number of researchers suggest that video has the potential to support teacher learning because it provides rich access to teaching and learning (Lampert & Ball, 1998; LeFevre, 2004). We contribute to this conversation by unpacking some of the ways a video clip provides such access and, in particular, access to student mathematical thinking. Such information is valuable for researchers who study video-based professional development because it highlights an important contextual feature that interacts with the learning that may be observed. Furthermore, this study provides teacher educators and others who design and use video-based materials information concerning how to select video clips to promote substantive analyses of teaching and learning. In addition, teachers in the United States today have opportunities to videotape and analyze their own teaching in a variety of settings, whether for National Board certification, early teacher induction, or preservice education. Such contexts increasingly call for teacher autonomy in the selection of videos to be viewed. Our work offers specific suggestions that may help teachers chose video that will allow them to engage deeply in thinking about their teaching.

Finally, if we take the situative perspective seriously, then we must also be aware that the video clips themselves are not the only factors that determine the quality of video club discussions. For example, in this video club, the facilitator likely played an important role in supporting the teachers' examination of student thinking. The facilitator had as her explicit goal to help the teachers learn to interpret students' ideas and to use evidence from the video to do so (van Es & Sherin, 2008). It seems possible that the facilitator may have implemented this goal somewhat differently depending on the nature of the video clip, adding another layer to the ideas we have presented thus far. Furthermore, the context in which our study took place was a video club in its initial year. Thus, over the time period in which our analyses take place, the participants were likely developing group norms and establishing shared language (van Es, 2009). Although we attempted to adjust for this in our selection of video club meetings to analyze, looking across the entire data corpus may reveal that teachers respond differently to certain kinds of clips over time. Ongoing analyses are exploring both of these issues.

One additional contextual feature that we suspect may have influenced the nature of the teachers' discussions relates to the fact that the clips viewed came from the teachers' own classrooms. As we have discussed, this feature limited our ability to select videos that portrayed student thinking in pre-established ways. At the same time, however, perhaps precisely because the clips portrayed interactions from teachers' own classrooms, excerpts that might otherwise not have served as catalysts for productive discussions did so. For instance, the teachers' interest in exploring student thinking that appeared low in depth on the videos may have been tied to the fact that the students portrayed were students they knew, working on activities with which they were familiar. We are in the beginning stages of designing a set of video club modules that offer videos and support materials for use in a video club format. Exploring the use of these modules and specifically the ways in which teachers respond to video clips of student thinking exclusively from others' classrooms will help us to better understand this issue.

Appendix
Detailed Coding of Selected Video Clips and Video Club Discussions

Clip No.	Teacher	Mathematical Topic	Participant Structure	Clip Coding			Discussion Coding			Productivity
				Windows	Depth	Clarity	Student Thinking	Mathematical Substance	Joint Sense Making	
2a	Frances	Comparing fractions	Whole class discussion	Low	Low	High	Low	Low	Med	Less productive
2b	Frances	Equivalent decimals and fractions	Whole class discussion	Low	High	High	Low	Low	Low	Less productive
2c	Daniel	Equivalent decimals and fractions	Student-to-student	High	High	High	High	High	Med	More productive
4a	Yvette	Multiplying numbers up to 10	Student-to-student	High	Low	Low	High	High	High	More productive
4b	Daniel	Multiplying by multiples of 10	Student-to-student	Low	Low	Low	Low	Low	Low	Less productive
8a	Frances	Multiplying fractions	Small group with teacher	Low	Med	Low	Low	Low	Low	Less productive
8b	Frances	Multiplying improper fractions	Student(s) present solution at board	High	Low	High	Low	Low	Low	Less productive
8c	Drew	Ratios and scale factors	Whole class discussion	High	High	High	High	High	High	More productive
8d	Daniel	Ratios and scale factors	Whole class discussion	High	High	Low	High	High	Med	More productive
8e	Daniel	Ratios and scale factors	Whole class discussion	High	High	Low	High	High	High	More productive
10a	Wanda	Combinations	Student-to-student	High	Low	Low	High	High	High	More productive
10b	Yvette	Equivalent fractions, decimals, and percentages	Whole class discussion	Low	Low	High	Low	Med	Low	Less productive
10c	Yvette	Equivalent fractions, decimals, and percentages	Whole class discussion	Low	Med	High	Low	Low	Med	Less productive
10d	Daniel	Multiplying decimals	Student(s) present solution at board	High	High	Low	High	High	High	More productive

Notes

1. For example, a video clip in which a student explains his or her use of the traditional multiplication algorithm would be considered low in depth if the student simply states step-by-step how he or she found the solution to a given problem. If, however, the student includes references to why the algorithm worked or why he or she followed the steps that he or she did, a great deal more depth and reasoning are likely to be portrayed.

2. The third author was the primary facilitator for the video club meetings.

3. For more information on the kinds of topics raised by the teachers for discussion, see van Es and Sherin (2008) and van Es (2009).

4. Our characterization of some discussions as "less productive" refers only to the extent that the teachers productively examined student mathematical thinking. We are not making claims that such conversations were useless for teachers or that no issues were considered in a depth.

5. All names are pseudonyms.

6. See the appendix for more information concerning the coding of each discussion dimension.

7. Clips are identified by a number representing the video club meeting and a letter representing the order in which the video clips were viewed. Thus, Clip 2a is the first clip shown in the second video club, and Clip 4b is the second video clip shown in the fourth video club meeting.

References

Ball, D. L. (1991). Research on teaching mathematics: Making subject-matter knowledge part of the equation. In J. Brophy (Ed.), *Advances in research on teaching: Vol. 2* (pp. 1-48). Greenwich, CT: JAI Press.

Ball, D. L. (1997). What do students know? Facing challenges of distance, context, and desire in trying to hear children. In B. J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (Vol. II, pp. 769-818). Dordrecht, the Netherlands: Kluwer.

Ball, D. L., & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In B. Davis & E. Simmt (Eds.), *Proceedings of the 2002 Annual Meeting of the Canadian Mathematics Education Study Group* (pp. 3-14). Edmonton, Alberta, Canada: Canadian Mathematics Education Study Group / Groupe Canadien d'étude En Didactique des Mathématiques.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional development. In G. Sykes & L. Darling-Hammond (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3-32). San Francisco: Jossey-Bass.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389-407.

Behr, M. J., Harel, G., Post, T., & Lesh, R. (1992). Rational number, ratio, and proportion. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 296-333). New York: Macmillan.

Boaler, J., & Humphries, C. (2005). *Connecting mathematical ideas: Middle school video cases to support teaching and learning*. Portsmouth, NH: Heinemann.

Brophy, J. (2004). *Using video in teacher education*. San Diego, CA: Elsevier.

Carpenter, T. P., Fennema, E., Peterson, P. L., & Carey, D. A. (1988). Teachers' pedagogical content knowledge of students: Problem solving in elementary arithmetic. *Journal for Research in Mathematics Education*, *19*, 385-401.

Chamberlin, M. T. (2005). Teacher discussions of students' thinking: Meeting the challenge of attending to students' thinking. *Journal of Mathematics Teacher Education*, *8*(2), 141-170.

Cohen, S. (2004). *Teacher's professional development and the elementary mathematics classroom: Bringing understandings to light*. Mahwah, NJ: Lawrence Erlbaum.

Engestrom, Y. (1999). Activity theory and individual and social transformation. In Y. Engestrom, R. Meittinen, & R. Punamaki (Eds.), *Perspectives on activity theory* (pp. 19-38). New York: Cambridge University Press.

Gamoran, A., Anderson, C. W., Quiroz, P. A., Secada, W. G., Williams, T., & Ashmann, S. (2003). *Transforming teaching in math and science: How schools and districts can support change*. New York: Teachers College Press.

Goldin-Meadow, S. (2004). Gesture's role in the learning process. *Theory Into Practice*, *43*(4), 314-321.

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

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. Berliner & R. Calfee (Eds.), *Handbook of educational psychology* (pp. 15-41). New York: Macmillian.

Hiebert, J., Morris, A. K., Berk, D., & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education*, *58*, 47-61.

Hiebert, J., & Stigler, J. W. (2000). A proposal for improving classroom teaching: Lessons from the TIMSS Video Study. *Elementary School Journal*, *101*, 3-20.

Horn, I. S. (2005). Learning on the job: A situated account of teacher learning in high school mathematics departments. *Cognition and Instruction*, *23*(2), 207-236.

Kagan, D. M., & Tippins, D. J. (1991). Helping student teachers attend to student cues. *The Elementary School Journal*, *91*(4), 343-356.

Kazemi, E., & Franke, M. L. (2004). Teacher learning in mathematics: Using student work to promote collective inquiry. *Journal of Mathematics Teacher Education*, *7*, 203-235.

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

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

LeFevre, D. M. (2004). Designing for teacher learning: Video-based curriculum design. In J. Brophy (Ed.), *Using video in teacher education* (pp. 235-258). San Diego, CA: Elsevier.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teacher understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum.

Mehan, H. (1979). *Learning lessons*. Cambridge, MA: Harvard University Press.

Merseth, K. K. (1996). Cases and case methods in teacher education. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (pp. 722-744). New York: Macmillan Library Reference.

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

Nikula, J., Goldsmith, L. T., Blasi, Z. V., & Seago, N. (2006). A framework for the strategic use of classroom artifacts in mathematics

professional development. *NCSM Journal of Mathematics Education Leadership*, *9*(1), 57-64.

Oonk, W., Goffree, F., & Verloop, N. (2004). For the enrichment of practical knowledge: Good practice and useful theory for future primary teachers. In J. Brophy (Ed.), *Using video in teacher education* (pp. 131-167). San Diego, CA: Elsevier.

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.

Rosaen, C. L., Degnan, D., VanStratt, T., & Zietlow, K. (2004). Designing a virtual K-2 classroom literacy tour: Learning together as teachers explore "best practice." In J. Brophy (Ed.), *Using video in teacher education* (pp. 169-199). San Diego, CA: Elsevier.

Roschelle, J. (2000). Choosing and using video equipment for data collection. In A. Kelly and R. Lesh (Eds.), *Handbook of research design in mathematics and science education* (pp. 709-731). Mahwah, NJ: Lawrence Erlbaum.

Schifter, D. (1998). Learning mathematics for teaching: From the teachers' seminar to the classroom. *Journal for Mathematics Teacher Education*, *1*(1), 55-87.

Seago, N. (2004). Using video as an object of inquiry for mathematics teaching and learning. In J. Brophy (Ed.), *Using video in teacher education* (pp. 259-286). San Diego, CA: Elsevier.

Seago, N., Mumme, J., & Branca, N. (2004). *Learning and teaching linear functions: Video cases for mathematics professional development, 6-10*. Portsmouth, NH: Heinemann.

Seidel, S. (1998). Wondering to be done: The collaborative assessment conference. In D. Allen (Ed.), *Assessing student learning: From grading to understanding* (pp. 21-39). New York: Teachers College Press.

Sherin, M. G., & Han, S. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education, 20*, 163-183.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, *15*(2), 4-14.

Shulman, L. (1996). Just in case: Reflections on learning from experience. In J. A. Colbert, P. Desberg, & K. Trimble (Eds.), *The case for education: Contemporary approaches for using case methods* (pp. 197-217). Boston: Allyn and Bacon.

Smith, M. S. (2000). Balancing old and new: An experienced middle school teacher's learning in the context of mathematics instructional reform. *Elementary School Journal*, *100*(4), 351-375.

Smith, M. S. (2002). *Practice-based professional development for mathematics teachers*. Reston, VA: National Council of Teachers of Mathematics.

Stein, M. K., Baxter, J. A., & Leinhardt, G. (1990). Subject-matter knowledge and elementary instruction: A case from functions and graphing. *American Educational Research Journal*, *27*, 639-663.

Stein, M. K., Grover, B. W., & Henningsen, M. (1996). Building student capacity for mathematical thinking and reasoning: An analysis of mathematical tasks used in reform classrooms. *American Educational Research Journal*, *33*(2), 455-488.

Towers, J. (1998, April). *Close encounters of the complex kind: Using videotape in teacher education*. Paper presented at the Annual Meeting of the American Educational Research Association, San Diego, CA.

van Es, E. A. (2009). Participants' roles in the context of a video club. *Journal of the Learning Sciences*, *18*(1), 100-137.

van Es, E. A., & Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, *24*, 244-276.

Wang, J., & Hartley, K. (2003). Video technology as a support for teacher education reform. *Journal of Technology and Teacher Education*, *11*(1), 105-138.

Webb, J. M., Diana, E. M., Luft, P., Brooks, E. W., & Brennan, E. L. (1997). Influence of pedagogical expertise and feedback on assessing student comprehension from nonverbal behavior. *The Journal of Educational Research*, *91*(2), 89-97.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. In A. Iran-Nejad & P. D. Pearson (Eds.), *Review of research in education* (pp. 173-209). Washington, DC: American Educational Research Association.

Miriam Gamoran Sherin is an associate professor of learning sciences in the School of Education and Social Policy at Northwestern University. Her research interests include mathematics teaching and learning, teacher cognition, and the role of video in teacher learning. Recent articles appear in *Teaching and Teacher Education* and *Journal of Curriculum Studies*.

Katherine A. Linsenmeier teaches mathematics at New Trier High School in Winnetka, Illinois, and studies mathematics teaching and learning at Northwestern University. Recent articles appear in the *Journal of Mathematics Education Leadership* and *Teaching Children Mathematics*.

Elizabeth A. van Es is an assistant professor in the Department of Education at the University of California, Irvine. Her research interests include teacher thinking and learning and the design of teacher education and professional development. Recent articles appear in *Journal of the Learning Sciences* and *Teaching and Teacher Education*.