

Designing Video-based Teacher Professional Development: Teachers' Meaning Making with a Video Annotation Tool*

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In this research, we designed a teacher professional development (PD) program where a small group of mathematics teachers could share, reflect on, and discuss their pedagogical knowledge and practices of ICT-integrated lessons, using a video annotation tool called DIVER. The main purposes of this paper are both micro and macro: to examine how the teachers were engaged in the meaning-making process in a video-based PD (micro); and to derive implications about how to design effective video-based teacher PD programs toward a teacher community of practices (macro). To examine teachers' meaning-making in the PD sessions, discourse data from a series of 10 meetings was segmented into idea units and coded to identify discourse patterns, focusing on (a) participation levels, (b) conversation topics, and (c) conversation depth. Regarding the affordance of DIVER, discourse patterns of two meetings, before and after individual annotation with DIVER were compared through qualitative vignette analysis. Overall, we found that the teacher discourse shifted the focus from surface features to deeper pedagogical issues as the PD sessions progressed. In particular, the annotation function in DIVER afforded the teachers to exercise descriptive analyses of video clips in a flexible manner, thereby helping them cognitively prepared to take interpretative and evaluative stances in face-to-face discussions with colleagues. In conclusion, deriving from our research experiences, we discuss the possibilities and challenges of designing video-based teacher PD in a school context.

Keywords: Teacher learning, Teacher professional development, Video technology, Annotation, Community of practice

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Introduction

The situated perspective of teacher learning suggests that the activities, discourses, and tools used by a teacher community are important to influence teacher learning (Lave & Wenger, 1991; Stuckey & Barab, 2007). In particular, the concrete artifacts used by a teacher community, such as lesson planning, students' work, and classroom videos, can contribute to the development of a situated context for teachers. In more than a decade of teacher learning research, video technology has been suggested as a promising platform for such a situated context by bringing performative aspects of teaching practices to the fore and for anchoring teacher reflections and discussions through the sharing of vivid images of classroom practices and discourses (Brophy, 2004; Quinn, Kane, Greenberg & Thal, 2015; Sherin, 2007; Trip & Rich, 2012)

However, sharing teaching practices and artifacts is not a pervasive culture for most school teachers. In the previous research project, we found that while teachers and school leaders had rich insights about their beliefs and pedagogical knowledge, they often relied on individual practices isolated from other teachers, and had little opportunities to share and refine their pedagogies with their colleagues (Jacobson et al., 2010). To overcome this issue, we designed an in-service teacher professional development (PD) program where a small group of teachers could share, reflect on, and discuss their pedagogical knowledge and practices using video tools that allow for collaborative sharing and annotations. In this paper, we report findings on how the teachers were engaged in the meaning-making process in the PD sessions, supported through a video collaboratory tool called DIVER (Digital Interactive Video Exploration & Reflection), which is a solution to remove constraints of time and space that teachers often face.

The structure of this paper is as follows. We first present theoretical perspectives underlying this research program, that is, the notion of a Community of Practice

(CoP) and video technology for artifact-based teacher PD. Then, we explain the design of the in-service teacher PD program together with affordances of DIVER. The results section presents findings regarding the discourse patterns of teachers' meaning-making and teachers' perceptions about impacts of the video-based teacher PD. The paper concludes with the possibilities and challenges of designing video-based PD development in a school context.

Theoretical Background

Towards a community of practice as a model of teacher professional development

Since Lave and Wenger's (1991) exposition of the construct of *Communities of Practice* (CoPs), one strategy that is deemed promising is teacher professional development through the fostering of CoPs, which provides a valuable platform for teachers to connect and interact among themselves, to share and support each other on the specific problems, experiences and lessons learned, and to do so at their own time and pace. Problem-solving in this context is not an academic exercise but a means towards finding a practical and informed resolution in matters that have implications to the society and others. Communities of practice thus reflect a constructivist, in-situ social approach to teacher learning that is rather different from the current practices adopted in traditional professional development and consistent with professional learning in other professions (Brown & Duguid, 2000; Stuckey & Barab, 2007).

Why is constructing CoPs a suitable strategy for teacher professional development? Learning in the mode of practice is not merely the transfer of knowledge from the group to the individual, but reciprocal; the individual is both transformed by the group and in return transforms the group (Rogoff, 1994). It is

such a whole-person development approach that CoP advocates, making it appealing as a locus of and catalyst for professional development. The mutual (individual-collective) benefiting mantra is attractive to organizational leaders who have to provide opportunities for individual advance yet progresses the collective. In partnership with colleagues, teachers can struggle with the uncertainties of their profession and receive support, mentoring, and coaching (Darling-Hammond & McLaughlin, 1995). Also central to CoP is the notion of learning in-situ or situated learning. Knowledge is dynamically constructed as we conceive of what is happening to us, talk, and move (Clancey, 1995). Following this view, learning is also performative – how well a teacher performs in the practice as he/she participates within the community. Knowledge is contextualized and “resides” within the practice. Novice teachers learn from the experienced; school problems are solved collectively; and there is less need for external consultants to conduct de-contextualized training. Both “inside and outside” knowledge are necessary and must be in proper balance for teacher learning. Too much emphasis on either can militate against improvement.

Video technology for teacher learning

Video technology has been suggested as an effective medium that teachers can share vivid images of teaching and learning practices in classrooms (Fishman & Davis, 2006). The reasons on why video might have the potential to support teacher learning have been well expounded in detail by Sherin (2007). These include the representation power of videos in documenting the complex and nuanced interactions in the classroom, which videos far surpass researcher ethnographers’ field notes. Not only are videos a close representation of reality, viewers are able to make varied interpretations of the same footage through repeated playback, thereby enabling multiple perspectives in sense making. Second, human perspectives, how objective we try to be, contain a certain degree of attentional biases, which we argue

that in a continual wide-angle video documentary has significantly less.

Due to its ability to capture the dynamicity of an authentic classroom and to be a lasting record for later reflection and analysis, video has been used widely as an important tool for teacher professional development. A popular application is setting participants in the context of a community discussion based on classroom videos. Here, video as a medium plays an important role for teachers' meaning making during discussion. Many studies evidenced that a well-designed video-based discussion is effective for the development of teachers' understanding of subject-matter concepts, situated knowledge of instructional strategies, and abilities of professional thinking and noticing of student learning (Borko, et al., 2008; Kleinknecht & Schneider, 2013; Santagata, 2009; Zhang et al., 2011).

A series of research studies on the "Video Club" program by Sherin and colleagues provide a good example of teacher learning through analyzing video segments collaboratively under the assistance of researchers (e.g., Sherin & Han, 2004; Sherin, 2007; Sherin & van Es, 2009; Sherin, Linsenmeier, & van Es, 2009, van Es & Sherin, 2008). A video club is a face-to-face discussion context based on videos among a group of teachers. The teacher professional development processes in this program is described in Figure 1. As the practices going forward, Sherin and colleagues observed significant changes of what the teachers discussed in the video clubs and how they discussed pedagogical issues. For instance, the focus of teacher discourse shifted from their own actions to students' actions and thinking process, and from surface features to deeper pedagogical issues (see Table 1). Sherin (2007) argues that teachers can have meaningful discussion around authentic classroom videos at a group level, and their conversations evolved in meaningful ways over time. Observations of such evolvments enable researchers to understand what and how teachers learn in the community of practice. The mechanism of changes in such a context, however, need further study.

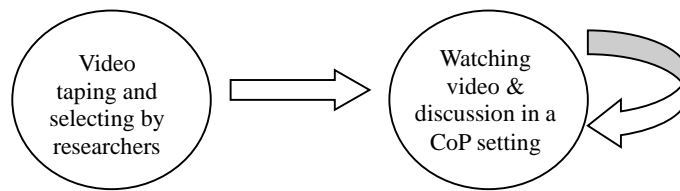


Figure 1. Video Club program

Table 1. Changes of teacher discourse before and after their participation in video clubs

		Before	After
What	Discourse focus	Teachers' actions and decisions	Students' actions and ideas
	Discussion of student thinking	Restatement of students' ideas	Analysis of student thinking
How	Discussion of pedagogical issues	Explaining teaching methods and offering alternative pedagogical strategies	Examining pedagogical issues in terms of student thinking

Borko and colleagues (2008) conducted a similar study that video as a tool could help foster productive discussion among mathematics teachers. This project was based on the Problem-Solving Cycle (PSC) model wherein teachers firstly solved problems and developed lesson plans; then implemented lessons and discussed around videos from their classroom together. This program is similar to the structure of “lesson study”, which is detailed by Lewis, Perry and Murata (2006) in the sense that the teachers collaboratively planned the lesson and conducted and videotaped the same lesson for later discussion. Borko (2008), however, indicates that “a key difference is that lesson study is focused on designing, carrying out, and reflecting on a specific lesson, whereas the PSC is focused on solving, teaching, and learning from a specific mathematics problem” (p.434). Teacher discussions in the Problem-Solving cycle were scaffolded by some specific topics about teacher’s role or students’ role. The research result suggests that the teachers in the program engaged in increasingly reflective and productive group-level conversations around videos; that is, the teachers discussed pedagogical problems more in-depth and

analytically as the project progressed.

A study by Santagata (2009) presented another example of designing video-based professional development. This research has a particular focus on helping mathematics teachers from low-performing schools, and was conducted through three processes, including (a) content exploration, (b) lesson analysis and (c) link to practices. For content exploration and lesson analysis, some video cases that aimed at helping teachers solve specific instructional problems were provided for teachers to analyze. For the link to practices, teachers implemented the lesson that they analyzed previously. Based on such experiences, Santagata (2009) provided some principles about designing video-based professional development for teachers, namely “(a) attending to content-specific understanding, (b) scaffolding analysis of student thinking, and (c) modeling a discourse of inquiry and reflection on the teaching and learning process” (p.50).

Beyond the general discussion about the advantages of video technology for teacher learning, more recent studies appear to focus on specific design mechanisms underlying effective video-based professional development. For instance, Zhang et al. (2011) examined how the affordances of different types of video – published video, teachers' own video, and peers' video – could improve teacher learning and reflective practices in a video-based professional development for science teachers. They found that there are unique values and challenges associated with each type of video, and that it is important to engage teachers in both individual and collaborative reflection with their video in a learning community. van Es and colleagues (2014) focus on the fact that simply viewing video does not mean teacher learning. Hence they examined how to facilitate teachers' discourse and analytical activities in order to engage teachers in a productive and generative learning process. They suggest a framework for facilitating video-based professional development that includes (a) orienting the group to the video analysis task, (b) sustaining an inquiry stance, (c) maintaining a focus on the video and the content knowledge and (d) supporting group

collaboration.

The focus of the present study

On the whole, the existing literature indicates that video technology holds much potential for teacher learning, especially reflective practices. Yet little is known about specific mechanisms regarding how to design effective video-based teacher PD. That is, simply engaging teachers in video-viewing activities does not guarantee meaningful learning process and outcomes. Therefore, the main purpose of this study is to examine what is the mechanism that makes video-based teacher PD effective through a case study of a small group of teachers who participated in video-based teacher PD.

To further strengthen our case on why video technology for teacher learning, we felt that given the recent development of video analytical tools, annotations, amongst many other features, have good potential in facilitating discussions around concrete objects, i.e., video footages and their associated annotations and transcriptions (Rich & Hannafin, 2009). Video annotation tools examined in the previous research include DIVER (Pea & Lindgren, 2008), Video Analysis Support Tool (VAST) (van Es & Sherin, 2002), and Video Interactions for Teaching and Learning (VITAL) (Preston et al., 2005) as well as the commercial programs such as iMovie, Transana and Stuidocode. Such video annotation tools can not only elicit teachers' sense making around their practices and knowledge in situated ways, but also facilitate in-depth analysis of interactions, both discourse and actions, on a moment-by-moment basis. Such analytical power in videos surpasses other modes of data forms such as audio transcriptions of which actions are described in words, which at times can be difficult to visualize.

Despite the affordances of video annotation tools, there is limited research addressing their impact on in-service teachers. Most research studies published on this topic tend to examine pre-service teachers in structured courses and training contexts, where video annotation activities are rather mandatory and highly

scaffolded (Santagata& Guarino, 2010). We believe that using video annotation tools in school-based teacher PD contexts are likely to be different from its use in pre-service contexts due to the private nature of teaching practices and school culture. Hence, the main purposes of this paper are to examine how the teachers were engaged in the meaning-making process through annotated video formats, and to derive implications about how to design effective video-based teacher PD programs in a school context.

Method

Research questions and context

In this study, we are aware that a video annotation tool itself alone does not provide quality professional development for teachers. The research questions of this paper, therefore, are both micro and macro: (1) how were the teachers engaged in the meaning-making process through DIVER? (micro); and (2) what are implications about designing effective video-based teacher PD programs toward a teacher community of practices? (macro). In particular, we explored the hybrid format of video-based PD where teachers are engaged in both individual and collaborative annotation activities in online and offline settings, leveraging the affordances of DIVER (see elaboration in the next section).

To address these research questions, a group of five mathematics teachers (4 females and 1 male) at one Secondary school in Singapore participated in the video-based teacher PD program for one academic semester. As seen in Table 2, all of them were experienced teachers with eight to 26 years of teaching experiences. Four of them taught in this school for more than nine years. Their IT level is mostly basic with some training in software programs. None of them had used video annotation tools prior to this PD program.

Table 2. Participant profiles

Name*	Tina	Jane	Nancy	Linda	Allan
Gender	Female	Female	Female	Female	Male
Years in service	8	10	12	15	26
IT training	Nil	Photoshop	Blogging	Geometer's Sketchpad (GSP); Excel; IT Coordinator	GSP; Excel; Dbase

* Teacher names are pseudonyms for confidentiality.

Designing video-based teacher professional development

Overall design

The design for teacher PD in this research is an adapted lesson study (Lewis, Perry, & Murata, 2006) (see Figure 2). First, teachers together with researchers are to study the curriculum and to identify topics of interest for examination. In this study, one major condition in the identification of topics was the suitability for technology integration. That is, we specifically asked the teachers to identify a topic for lesson planning that could be better taught with the integration of technology components. Next, teachers are to write or revise their instructional plans for implementation to be video-taped. All teachers take turns to video-tape own lessons. As opposed to Lewis et al.'s (2006) lesson study where teachers congregate to observe a particular teacher in action in the classroom; in this project, we had all teachers to annotate individually the video of a particular teacher using DIVER. These annotations were then compared, discussed, examined and negotiated as a group when the teachers met together with the researchers in the weekly meeting, which was for approximately one hour. We believe that this design of teacher PD model can combine the strengths of lesson study practices and video technologies.

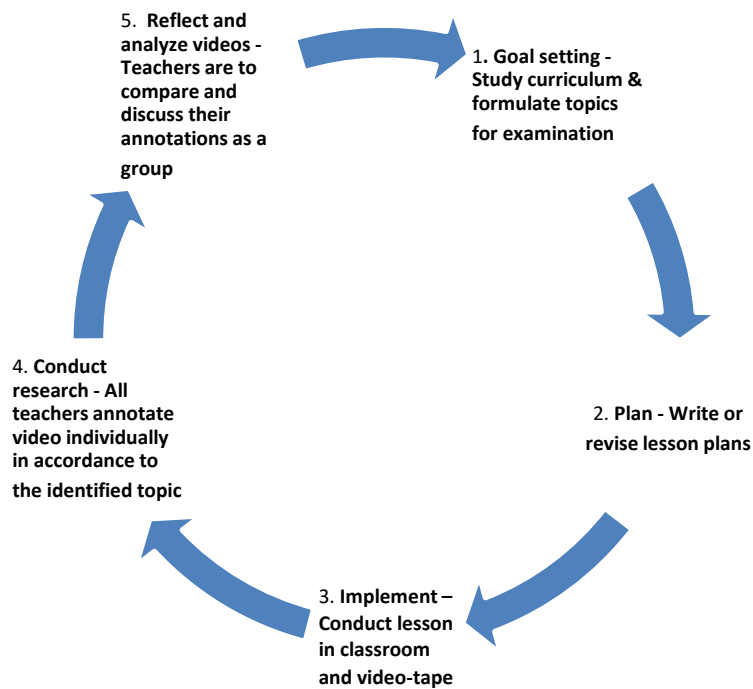


Figure 2. Depiction of an adapted lesson study cycle

Table 3 is a summary of main activities in a series of 10 meetings that this paper focuses on. To explain the activities briefly, the first meeting was to introduce each member including both participating teachers and researchers and to set arrangement for subsequent meetings. Starting from the second meeting to the fifth meeting, the teachers were engaged in discussing and sharing ideas for lessons plans in the Math curriculum that could integrate ICT as a core component. This was to promote pedagogical discussions through collaborative lesson planning activities. Meeting 6 was to provide the teachers with technical training on how to use DIVER. Prior to Meeting 7, selected video clips of lessons from teachers who volunteered to video-tape for collective viewing were uploaded to DIVER. Meetings 7 and 8 were devoted to promote teachers' meaning-making around the annotated video clips. The last two meetings were to consolidate discussions and to plan for the next round of lesson planning activities.

Throughout the face-to-face meetings, the facilitators (who are the authors of this paper) scaffolded teacher discourse by posing analysis-leading questions such as “what do you notice?”, “what is your evidence?” and “what is your interpretation?” In addition, for the online video annotation activity, we scaffolded the teachers to select critical events and significant interactions by selecting *what* (unclear parts), *wow* (new ideas and interesting observations), and *hmm* (wonderment questions such as students’ mistakes or misconceptions) clips, which is the idea taken from Linsenmeier and Sherin (2007).

Table 3. Summary of meeting activities

Purpose	Meeting No.	Main Activities
Arrangement	1	Introduction and arrangement of later work
Lesson	2	Examining ICT resources
Planning	3	Discussing ICT-related pedagogical issues
	4	Sharing and discussing lesson plans
	5	Sharing and discussing lesson plans
Discussion & Reflection	6	DIVER training Video taping selected lessons
	7*	Discussion & reflection around video * Annotation done during the meeting
	8*	Discussion & reflection around annotated video * Annotations done prior to the meeting
Consolidation	9	Feedback and plan for the next round
Planning	10	Round two of lesson plan

* *Note:* Data from Meetings 7 & 8 is for qualitative vignette analysis.

Collaborative video annotation tool

DIVER supports collaborative annotation and analysis for shared meaning-making across multiple perspectives. For instance, DIVER provides a *guided noticing* function that allows “participants to negotiate the identity of a referent and its meaning over progressive conversational turns” (Pea & Lindgren, 2008, p.239). This is to avoid referential ambiguity and to facilitate attentional alignment. Below are the brief descriptions of DIVER’s main features (see Figure 3):

- *DIVE panel*: The block that contains the frame/video segment, separated by a line break. Currently selected panel will be highlighted in blue. A panel can be selected by clicking on the thumbnail.
- *Worksheet*: A list of individual DIVE panels consisting of marked frames and recorded video segments.
- *Mark*: The mark button allows users to create a reference for a specific frame in the video.
- *Record*: The record button allows users to record a video segment.
- *Guided noticing*: a) highlighting specific aspects of a scene, and b) providing an interpretation of the aspects of the scene to capture viewers' attention.

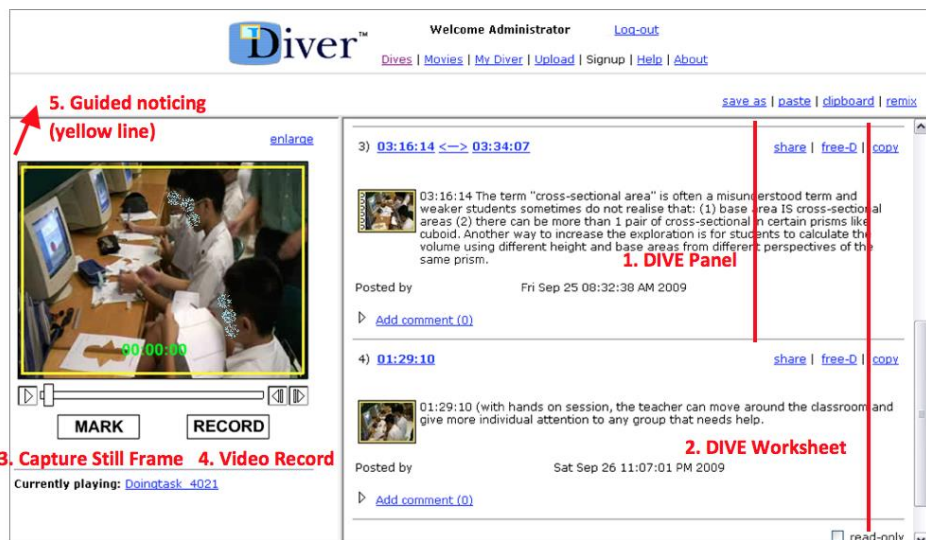


Figure 3. DIVER user interface

Data collection and analysis

For data collection, a total of ten meetings were recorded, each lasting for approximately one hour. All ten meetings were transcribed verbatim for discourse analysis. Following the analytical approach employed by Borko et al. (2008), we

conducted a qualitative vignette analysis of selected meetings. In this paper, data from Meeting 7 and Meeting 8 were selected for a vignette analysis, given that these two meetings were conducted around the use of DIVER. In Meeting 7, video annotation was done collaboratively during the face-to-face meeting whereas teachers did individual annotation in a flexible manner prior to Meeting 8. Our aim of the vignette analysis of Meetings 7 and 8 is to illustrate how the teachers were engaged in the meaning-making process mediated by DIVER.

To examine interaction and discourse patterns over time, we segmented each meeting data into “idea units” (Jacobs & Morita, 2002). Meeting transcriptions were segmented into different idea units when a new idea unit emerged. Each idea unit was subsequently coded with reference to the dimensions proposed by Sherin et al. (2009) and van Es (2009): (a) participation levels, (b) conversation topics, and (c) conversation depth (i.e., description, interpretation and evaluation). Table 4 presents the detailed framework of coding. In addition to the meeting data, we also conducted face-to-face interviews with the participating teachers after Meeting 10 to examine their perceptions and experiences about the video-based teacher PD program.

Table 4. Coding framework

Dimension	Indicator	Descriptions
Participation level	Time duration	Actual time spent for each idea unit
	Initiation	Researcher or teacher who initiates each idea unit
	Number of participants	Number of participants in conversation (excluding researchers)
Conversation topic	Topic	What teachers discuss; Topics/themes that are dominant in each idea unit
Conversation depth	Stance	Three stances: 1. Describe, 2. Interpret & 3. Evaluate

Results

Discourse patterns and meaning-making

To examine how the use of videos and video annotations supports the emergence of productive and generative discussion, we selected discourse data from Meetings 7 and 8 for in-depth analysis and comparison. During the period of Meetings 7 and 8, the teachers participated in both collaborative and individual annotation on selected video clips. In the DIVER platform, we uploaded five video clips from lessons of two teachers who volunteered to videotape their lessons: one from Tina's, and four from Allan's, with an average length of 5 minutes for each clip. The topic of both lessons was "Ratio, Proportion and Scale". The selection of the video clips was done collaboratively through discussion between researchers and teachers, with an intentional focus to select parts of the lesson where technology components were integrated. The video from Tina's lesson was the first 9 minutes of her lesson on where she used a video clip to provide a scenario for the topic to promote students' interests and to anchor the learning activities. The other four videos were from Allan's lesson where students worked in groups to solve a collaborative task using the 3D math simulation program of cross-sectional areas. The first clip was the introductory part of his lesson. The next three video clips showed one group's processes of doing a collaborative task in stages: task distribution, task execution and task outcome respectively.

The focus of Meeting 7 was to have teachers identify and discuss ideas that they felt were salient vis-à-vis the use of DIVER. Specifically, videos were analyzed and annotated collaboratively during the meeting time. As summarized in Table 5, five idea units were identified with varied time duration from 1 minute to over 8 minutes. All the idea units were initiated by the facilitators. It appeared that the teachers spent some time conditioning themselves in the doing of reflections and annotation mediated by DIVER (idea units no. 2 & 3). Throughout the meeting,

the teacher stances showed were mostly at the descriptive level where they were trying to get a sense of what the learning activities in the videos were about. Annotations were mostly short and descriptive without much elaboration, such as the annotation “students are not paying attention” in Figure 4.

Table 5. Analysis of Meeting 7

Idea unit no.	Time (min:sec)	Initiated by	Topic	Details	Stance
1	3:10	F	Lesson introduction	Introduction to lesson implementation	Describe
2	8:40	F	Students' group work	Watching the videos in DIVER and discussing distribution of student work	Describe
3	8:30	F	Practice of annotation	Collaborative annotation in DIVER	Describe
4	1:00	F	Students' attitude	Students engagement in tasks	Describe & Interpret
5	1:25	F	Task design	Students' computer use for more on hands-on activities.	Describe & Interpret


Note: F=facilitator; T=teacher

For instance, when the facilitator asked whether the teachers noticed something interesting to them, what they shared was mostly descriptive of what they were seeing in the video rather than any in-depth discussion and interpretation. For illustration, the following excerpt shows that while the facilitator was trying to initiate a conversation about how and why the students were engaged or disengaged in the learning activities, the teachers were mainly discussing whether the students were noticing the fact that they were filmed. Also, the last comment by Tina shows a rather superficial interpretation of equating physical activities with cognitive engagement.

- Facilitator:* Ok from this video clip did you notice any interesting moments? The cutting activity? Cutting. So what you think about the cutting boy?
- Nancy:* looks like everybody is engaged.
- Facilitator:* everybody is engaged?
- Jane:* or is it they know that they are being filmed?
- Allen:* no not true
- Tina:* not true. Because my 102 (*class name*) even though they know they are being filmed, they act up
- Allen:* because this one looks very natural
- Nancy:* I saw someone putting up the hand, trying to ask you a question [laughs]
- Tina:* oh, you saw already ah?
- Nancy:* yea yea yea
- Facilitator:* so you think all of them are quite engaged in the activity
- Nancy:* That's right.
- Tina:* I think it's because they are given some hands on, so it's not passive, so that's why they are, and then they like to fiddle around with computer, so once put them in front of a terminal right, where they can do things huh, maybe that helps.

Dive: A_Lesson_Introduction **Owner:** Administrator NIE 3,

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some students are not paying attention. intructions and expectations are clearly spelled out.

Figure 4. Example of teachers' annotation done in Meeting 7

To help teachers take more interpretive stances in video annotation and reflection process, following week 7 we decided to provide the following guiding questions in DIVER:

- Is there evidence of students working collaboratively in the video clip?
- Do you think students are exploring substantive mathematical concepts and ideas?
- How does the use of technology help students' mathematical learning in the video clip?

Teachers were to post their annotations individually in response to these questions before Meeting 8. These annotations were used as the trigger for discussions in Meeting 8, (see Figure 5). As shown in Table 6, the range of conversation topics in the discourse data of Meeting 8 expanded to 10 idea units. Additionally, the stances teachers showed were more at the interpretive and evaluative level. Five idea units contained teachers' interpretative stances and four units with evaluative stances whereas only one idea unit was mainly descriptive. There were also two occasions (see idea units no. 5 and 9) where initiation shifted from the facilitator to the teachers. The range of topics also expanded and moved deeper including issues about student meta-cognition and misconception.

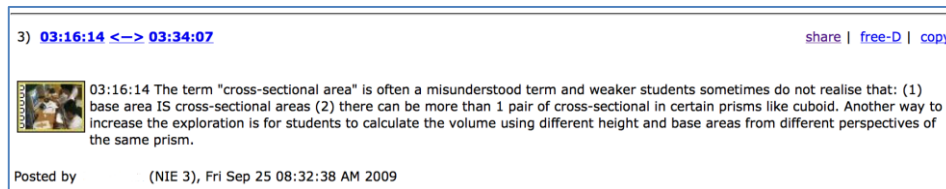


Figure 5. Example of teachers' annotation done prior to Meeting 8

Table 6. Analysis of Meeting 8

Idea unit no.	Time (min:sec)	Initiated by	Topic	Details	Stance
1	0:36	F	Teachers' annotation work	Talking about teachers' annotation at home and the focusing questions	Describe & evaluate
2	3:08	F	Student meta-cognition	Showing video to students for meta-cognition	Interpret
3	2:40	F	Student thinking	Drawing is the indicator of visualization	Interpret
4	2:20	F	Student collaboration	Whether the four boys were working together	Describe
5	0:30	F	Task design	Whether the workload is too much for students	Evaluate
6	2:30	F	Pedagogy	How to close the gap between seeing and doing	Interpret
7	2:30	F	Pedagogy	construction & de-construction of shapes	Evaluate
8	1:30	F	Pedagogy	Open question: concrete first or abstract first	-
9	3:50	F&T	Pedagogy	How to design the task to improve students' interaction	Interpret
10	4:40	F	Student misconception	Students' misconception about cross-sectional area	Interpret

Note: F=facilitator; T=teacher

Although we did not intentionally set out to do a comparative study between Meetings 7 and 8, evidenced in the results shown above, there are differences in the breadth and depth of idea generated. Apart from an increase in breadth in the number of idea units generated, there is an increase in depth in inquiring about student learning in Meeting 8. That is, rather than to have teachers annotate independently in a common time (Meeting 7), having teachers post annotations at their own time had open up the space in Meeting 8 for in-depth explorations of the

annotations. Overall, teachers in Meeting 8 were discussing in a deeper manner, such as the possible methods of closing the gap between seeing and doing when students learn about the cross-sectional area through visual hands-on activities, as presented in the excerpt below.

**F1 = facilitator 1, F2 = facilitator 2*

F1: so, you know I was just thinking back, the flow of the lesson is that they need to go to the website. I am not sure whether you have the chance to go to the website, which it has for animation of opening up a 3D right?

F2: because the one Allan shares with us yea, is animation// opening and folding.

F1: // that's right, opening up to a net diagram, so I think back to Tina's observation, showing that animation seems at this stage insufficient to bring them up to the level of drawing, so seeing and doing there is still a gap, it seems so far I mean that our discussion seems to be going in that direction... so it seems that the visual the seeing, and the actual of doing seems to exist a gap still, so any ideas how we can try and close this?

Allen: I think the boys probably don't have enough investigating type of activity, so they are not like know what to do ah, so actually we don't like really groom them to learn how to investigate something.

Linda: maybe we can bring concrete models for them to play with?

F1: you think that will help?

Linda: that might help a little, because any form of physical experience, with something abstract, does scaffold them a bit.

Allen: that's why they are making the net, right?

Linda: let them play with it, actual you know throw some cylinders, some cuboids all around the place, give them a visual you know like...

Allen: like your son?

Linda: I know very kidish but, given our roles were there very bad work, bad work, just weak spatial intelligence of this point.

Allen: so do you think like giving them like one cm cube and then they build the structure, then build up.

Linda: I mean any form whatever time will permit, what do you think?

Teacher perceptions

We firstly analyzed interview data to identify teachers' perceptions about the sense of a community of practices in this teacher professional development program, which this research program ultimately aimed to foster. All of the teachers believe that sharing is an important way to learn. Tina even said, "we can never learn without sharing". Even though they absolutely appreciated the importance of sharing, the atmosphere of sharing in the school context was not highly favorable and active. Most of the sharing activities were done in informal ways other than formally attending meetings and seminars. The extent of sharing tends to be narrow, mostly within a closed circle with a small group of teachers. During the interview, we found that most teachers' conception of sharing was limited to learning from others or making resources public for a group of people. None of them mentioned that sharing involves collaborative problem solving and creating new things at a community level.

Next, we analyzed teachers' perceptions regarding their participation in the video-based teacher professional development program. On the whole, the teacher felt that group discussions after individual annotative reflection were more productive than having them watch, discuss and annotate in a common time. For example, one teacher commented that the annotation exercise gave extra time and space to do reflections in a slower-paced and comfortable manner:

It kind of allows you time and space to slowly do it, and not confine to just the one hour, that was the luxury, that was the luxury, you know, you can do it like... you know when you've done with everything, so it's quite nice, I would say, yes, it's another way of doing thing, comfortable way.
(Linda)

Discussion and Conclusion

Recently, we have seen increasing interests in video-based programs for teacher

learning, and several researchers have developed video-based programs for such activities. However, little is known about the underlying mechanisms of how using video-based platforms affects artifact-mediated meaning co-construction among teachers. In this section, we visit each research question to discuss the implications of research findings.

Video-based teacher PD: Possibilities and challenges

The first research question concerns how the teachers were engaged in the meaning-making process in the teacher PD sessions. Regarding the affordances of DIVER, we found that as opposed to having teachers do annotations in a common time, annotations performed independently at teachers' own time prior to group discussion served as triggers facilitating productive conversations. The role of the annotations in this case facilitated descriptive stances in teachers to park out what they observed, and at the same time, moot the inquiring issue to be discussed face-to-face. As a consequence, face-to-face conversations covered more breadth and depth where teachers showed interpretive and evaluative stances. We interpret the role of annotations as triggers in this case that served as the foundations on which explorations on pedagogical issues were built upon.

This finding presents some implications concerning how video annotation tools should be used to facilitate teachers' meaning-making process. Our finding is consistent with the existing literature that simply engaging teachers in video analysis does not automatically guarantee meaningful learning (Borko et al, 2008; van Es et al., 2015). More explicit scaffolding is necessary to prompt teachers' annotation and reflection in a deeper manner. We observed the shift of focus in teacher discourse from surface features of student behaviors to pedagogical issues of student thinking. While our study does not support causal links between video annotations and teacher change, it is possible to provide some exploratory reasons. One explanation underlying this shift of focus is related to the scaffolding questions given to the

individual annotation. Often, teachers do not know what to look for in video clips. The focused guiding questions oriented the teachers to the specific problems, making the alignment between the content of video and the problems to analyze. Another potential explanation may be that the affordance of DIVER helped the teachers *learning how to notice* complex situations. With the function of guided noticing, repeated playback and annotation in DIVER, it is possible that the teachers became more attentive to what they saw in the video clips. Further, the individual annotation in DIVER in a flexible manner helped the teachers cognitively prepared for the group discussion in a face-to-face context.

Despite the promising results, we equally observed some structural challenges in designing and facilitating video-based teacher PD. One of the fundamental challenges is related to the culture of sharing and the school structure. As indicated in the teacher interview, sharing ideas and observing other colleagues' classes is not a pervasive culture in the school. Teachers were also concerned about making or receiving critical remarks about what they say and share. It is necessary to establish certain norms to help teachers feel comfortable making their lessons and annotations public. Another challenge is associated with the role and skill of facilitators. Unlike the context of pre-service teacher education where instructors can provide highly structured scaffolding, facilitators in school-based teacher PD have to deal with the emergent and unpredictable nature of teacher PD coupled with the limited time and resources available in a school context. This requires the facilitator to take flexible roles and perspectives that are sensitive to teachers' needs and contextual factors.

Practical Implications: Designing video-based teacher PD

Acknowledging the potential of video technology to facilitate teacher learning, the next step should be to think about how educators and researchers might be able to design effective video-based teacher professional development. LeFevre (2004)

contends that “we cannot consider video a curriculum perhaps anymore than we can consider a whiteboard and markers a curriculum...video can become a part of a curriculum for learning if it is designed to be used in intentional ways towards intentional learning goals”. Consistent with this view, effective video-based teacher professional development involves much more than simply engaging teachers in video-viewing activities. We believe that certain conditions and activity structures are likely to lead productive and generative discourse. Based on our research experiences, we attempt to provide some practical implications and suggestions regarding how to design video-based teacher PD programs in a school context as follows:

- *How to de-privatize teacher practices for a culture of sharing:* It is critical to create a safe environment where teachers feel comfortable making their lessons and ideas public. This can be done through establishing and negotiating acceptable rules together with participating teachers to build trustful and collegial relationships. This rule setting should be done at an initial stage of teacher PD to provide teachers with sufficient time to get familiar with. At a macro level, school leaders should be supportive of a culture of teacher sharing, by offering formal and informal avenues where teachers can share their tacit knowledge and resources with colleagues.
- *How to structure collaborative viewing activities:* The content of video clips is likely to shape what teachers see and say. To promote collaborative and productive discussions around video clips, it is important to establish observation guidelines with teachers. These guidelines should contain norms to help teachers engaged in productive problem-solving processes, beyond simply describing without much elaboration. The sense of co-ownership should be also built through collaborative activities, such as having a common problem to solve and performing a collaborative lesson planning and an execution of the co-designed lesson.
- *How to facilitate teachers’ interpretive and reflective practices:* As seen in this study,

the affordances of video annotation tools can be utilized to engage teachers in both collaborative and individual annotation. Firstly performing individual annotation in a flexible manner gives teachers a space for individual reflection and helps them cognitively prepared to take more interpretive and evaluative stances in face-to-face discussions with colleagues. In doing so, it is necessary to design structural analysis tasks to train teachers to focus on specific instances of classroom practices and student behaviors beyond easily observable features. For instance, in a video-based teacher PD program, a facilitator can design structural analysis tasks where teachers individually analyze and annotate critical events through scaffolding questions to select *what* (unclear parts), *wow* (new ideas and interesting observations), and *hmm* (wonderment questions such as students' mistakes or misconceptions) clips in their free time, using a video-annotation tool. Then, these clips can anchor collaborative discussion and annotation in subsequent face-to-face meetings.

Ultimately, introducing video-based teacher PD in a school context should aim to cultivate a teacher community of practice to de-privatize teaching practices by offering an avenue to share vivid images of classroom situations and to gain instructional support/feedback for continuous improvement.

Some limitations of this study should be noted. First, this study examined the experienced math teachers. Generalizing findings to novice teachers and teachers in other subject areas should be done with caution. Second, since the discourse data of the meetings was coded by one researcher, there is no measure of inter-rater reliability available in this study. Third, from our data, most of the discussions were initiated by facilitators. We have yet to see prevalence in teacher-initiated inquires. Lastly, this paper focused on discourse data from two specific meetings around video-based annotations. How the teachers sustained the culture of collaborative lesson planning and the video annotation tool toward a community of practices

remains to be seen.

In conclusion, despite these limitations, we believe that this paper presents an international perspective with the case study that contributes to deepening our understanding of complex ecologies of teacher learning mediated by video technology. It is hoped that this paper can make contributions to the research community by presenting the design of a new video-based teacher PD program and its impact on teachers' meaning-making.

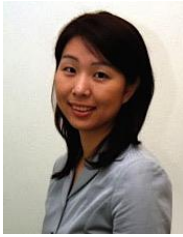
References

- Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education, 24*(2), 417-436.
- Brown, J. S., & Duguid, P. (2000). *The social life of information*. Harvard Business Press.
- Clancey, W. J. (1995). *A tutorial on situated learning*. Paper presented at the International Conference on Computers and Education Retrieved from <http://cogprints.org/323/0/139.htm>
- Colasante, M. (2011). Using video annotation to reflect on and evaluate physical education pre-service teaching practice. *Australasian Journal of Educational Technology, 27*(1), 66-88.
- Darling-Hammond, L., & McLaughlin, M. W. (1995). Policies that support professional development in an era of reform *Phi Delta Kappan, 76*(8), 597-604.
- Fishman, B. J., & Davis, E. (2006). Teacher learning research and the learning sciences. In K. Sawyer (Ed.), *Cambridge handbook of the learning sciences* (pp. 535–550). Cambridge: Cambridge University Press.
- Jacobs, J., & Morita, E. (2002). Japanese and American teachers' evaluations of videotaped mathematics lessons. *Journal for Research in Mathematics Education, 33*(3), 154-175.
- Jacobson, M. J., So, H. J., Teo, T., Lee, J., Pathak, S., & Lossman, H. G. (2010). Epistemology and learning: Impact on pedagogical practices and technology use in Singapore schools. *Computers & Education, 55*, 1694-1705
- Kleinknecht, M., & Schneider, J. (2013). What do teachers think and feel when analyzing videos of themselves and other teachers teaching?. *Teaching and Teacher Education, 33*, 13-23.
- 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. *Advances in research on teaching*, 10, 235-258. In J. Brophy (ed.) *Using video in teacher education (Advances in research on teaching, Volume 10)* (pp. 235-258). Oxford, UK: Elsevier.
- Lewis, C., Perry, R., & Murata, A. (2006). How should research contribute to instructional improvement? The case of lesson study. *Educational Researcher*, 35, 3-14.
- Linsenmeier, K., & Sherin, M. G. (2007). What?, Wow!, and Hmm...: Video clips that promote discussion of student math thinking. *Journal of Mathematics Education Leadership*, 10(1), 32-41.
- Pea, R., & Lindgren, R. (2008). Video collaboratories for research and education: An analysis of collaboration design patterns. *IEEE Transactions on Learning Technologies*, 1(4), 235-247.
- Preston, M., Campbell, G., Ginsburg, H., Sommer, P. & Moretti, F. (2005). Developing New Tools for Video Analysis and Communication to Promote Critical Thinking. In P. Kommers & G. Richards (Eds.), *Proceedings of EdMedia: World Conference on Educational Media and Technology 2005* (pp. 4357-4364). Association for the Advancement of Computing in Education (AACE).
- Quinn, D. M., Kane, T., Greenberg, M., & Thal, D. (2015). *Effects of a video-based teacher observation program on the de-privatization of instruction: Evidence from a randomized experiment*. Center for Education Policy Research. Harvard Graduate School of Education.
- Rich, P. J., & Hannafin, M. (2009). Video annotation tools technologies to scaffold, structure, and transform teacher reflection. *Journal of Teacher Education*, 60(1), 52-67.
- Rogoff, B. (1994). Developing understanding of the idea of communities of learners *Mind, Culture, and Activity*, 1(4), 209-222.
- Santagata, R. (2009). Designing video-based professional development for mathematics teachers in low-performing schools. *Journal of Teacher Education*,

60(1), 38-51.

- Santagata, R., & Guarino, J. (2010). Using video to teach future teachers to learn from teaching. *Zdm*, 43(1), 133-145.
- Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. In R. Goldman, R. Pea, B. Barron, & S.J. Derry (Eds.), *Video research in the learning sciences* (pp. 383-395). New York: Erlbaum.
- Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, 20(2), 163-183.
- Sherin, M. G., Linsenmeier, K. A., & van Es, E. A. (2009). Selecting video clips to promote mathematics teachers' discussion of student thinking. *Journal of Teacher Education*, 60(3), 213-230.
- Stuckey, B., & Barab, B. (2007). New conception of community design. In R. Andrews & C. Haythornthwaite (Eds.), *Handbook of e-learning research* (pp. 439-465). London: Sage.
- Tripp, T. R., & Rich, P. J. (2012). The influence of video analysis on the process of teacher change. *Teaching and Teacher Education*, 28(5), 728-739.
- 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. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, 10(4), 571-595.
- van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A framework for the facilitation of teachers' analysis of video. *Journal of Teacher Education*, 65(4), 340-356.
- Zhang, M., Lundeberg, M., Koehler, M. J., & Eberhardt, J. (2011). Understanding affordances and challenges of three types of video for teacher professional development. *Teaching and Teacher Education*, 27(2), 454-462.



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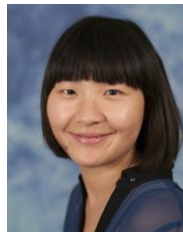


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