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Title	**Towards a model of effective use of video for teacher professional development**
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Citation	**The International Seminar, hosted by the national network of Science Learning Centres and University of York Science Education Group (UYSEG), York, U.K., February 2010.**
Issued Date	**2010**
URL	**http://hdl.handle.net/10722/129911**
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Towards a Model of Effective Use of Video for Teacher Professional Development

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Abstract: Based on previous research, this paper proposes an emerging model to outline the learning outcomes that teacher education programmes using video should consider. Besides cognitive and psychomotor learning, the affective and social needs of teachers are also highlighted in the model to inform the development of video-mediated teacher professional activities. Three broad strategies are identified in the model for bringing forth the learning outcomes, namely, critical reflection, meaningful comparison and productive discussion. These interact to shape the landscape of teacher professional learning. The model also identifies the key role of facilitators and the importance of video selection in enhancing teacher learning via video-mediated activities. It is suggested that the emergent model can serve as a heuristic guide on effective use of video for teacher professional development.

Keywords: Video, teacher professional development, learning outcomes

Introduction

Use of video for teacher professional development (TPD) has a long history going back to 1960s. It has progressed from being a means to expose teachers to specific behaviors to be imitated in microteaching settings to a tool for multi-purposes including the development of teachers' professional judgment. In this connection, Brophy (2004) reminds that video is a

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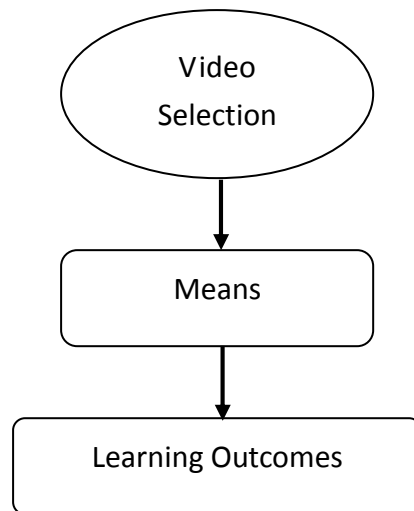[*] Corresponding author. Email: hwyung@hkucc.hku.hk

technology, not a curriculum. In selection of videos for TPD purposes, one needs to consider the curriculum goals and the means to achieve them. Yet in many studies, it is often assumed that the appropriate videos have been chosen for the intended TPD goals; information on how the videos are selected and what factors have been considered are rarely provided. Until recently, a few studies begin to look into this long-neglected and taken-for-granted, but crucial issue. For example, Sherin, Linsenmeier and van Es (2009) explore into the relationship between the types of video (i.e. video selection) and the quality of discussion that can be generated among the participant teachers (and hence the effectiveness of the TPD programme). However, the likelihood to generate productive discussion is only one of the many factors that TPD designers should consider in selecting videos for their courses. What are the other factors that TPD designers need to consider in selecting videos for their programme? To answer this question, we first conduct a review of the literature to identify the factors that may have a bearing on using video material for effective TPD. We then assemble these factors into a model of effective use of video for TPD. The proposed model will have practical and theoretical implications. In practice, it will serve as a heuristic device to guide the TPD designers in selecting videos and designing their courses. On the knowledge side, this model will provide a holistic theoretical framework of how various factors interact to affect teacher learning through the use of video. It should greatly enhance future development of research in this field.

Reviewing the literature and building the model

The design of a curriculum should begin with a consideration of its aims or learning outcomes, followed by the means to achieve the intended aims. Here, "means" refer to the video-mediated TPD activities. Hence, our initial model of effective use of video for TPD comprises three basic components: video selection, means and intended learning outcomes as depicted in Figure 1. Accordingly, we begin the literature review by focusing on the intended

learning outcomes of the TPD programmes, followed by an analysis of the "means" to achieve the outcomes.

Figure 1. An initial model of effective use of video for TPD

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The learning outcomes

Guskey (2002) suggests a 5-level evaluation model on the effectiveness of TPD programmes. He highlights the assessment of teacher learning according to the cognitive, psychomotor and affective goals. The cognitive objectives include promoting the participants' understanding of the teaching content, of the theories behind and the contexts while putting the new practices in classroom. On the other hand, psychomotor goals embrace the skills and practices the teachers can acquire from the learning experience. This dimension of assessment should also review how they practise the techniques in new contexts, that is, the impact of such programme on their teaching behaviour. Last, but not least, according to Guskey (2002), TPD programmes can also be evaluated with reference to their affective goals, for example, to develop teachers' attitudes, beliefs or dispositions for being professional teachers.

Although Guskey's model (2002) provides a guide for developing our model, it mainly focuses on three domains of teacher professional development, namely, the cognitive, psychomotor and affective domains. According to Bell & Gilbert (1996), this is not sufficient. They include in their TPD model a social domain where teachers in their course of

professional development find working in isolation problematic and feel the need to collaborate and work with peers. Indeed community building is becoming a feature for many TPD programmes recently (Putnam & Borko, 2000). Hence we also include the social domain in our model. In the following sections, we will review each of these domains one by one, albeit some programmes have multiple goals cutting across the four domains.

TPD targets within the psychomotor domain

Sharpe et al. (2003) provided a brief account of history of the early use of video for TPD purposes. The emphasis in developing teachers in the psychomotor domain stood out prominently. For example, Allen and Ryan (1969) used video for the purposes of microteaching; Greenburg (1971) used lesson videos of student teacher in conjunction with instructor supervision to improve physical education student teachers' teaching; Koorland and colleagues used the combination of videotaping and telephone conferences to improve teaching practice (Koorland, Tuchman, Wallat, Long, Thomson, & Silverman, 1985). To focus student teachers' attention on particular aspects of the teaching process, Jensen, Shepston, Connor and Killmer (1994) asked student teachers to videotape their lessons and then use a structured self-assessment form to evaluate their own performance in the areas of interpersonal skills, instructional management, organizational skill and questioning skills.

The developments in technology have provided more avenues to facilitate the training of student teachers' skills. Some educators (e.g. Admiraal et al., 1999) used videoconferencing as a tool to discuss classroom teaching with student teachers to train up their skills. Others use online discussion forum associated with video databases to help student teachers to reflect on their practices according to certain dimensions such as teaching skills, lesson designs and student participation (e.g. So, Pow, & Hung, 2009).

Besides teaching skills, recent studies also attempt to explore how video can raise teachers' awareness of the complexities of teaching and learning. For example, Borko, Jacobs,

Eiteljorg and Pittman (2008) selected a video clip and asked the teacher participants to carefully examine the questioning strategies of the teacher-in-video. Instead of focusing solely on the questioning techniques *per se*, as in earlier studies, the facilitators also highlighted the complex interplay among the teacher's role, the students' thinking, and the mathematics content. This brings us to a consideration of learning outcomes in the cognitive domain.

TPD targets within the cognitive domain

As behaviorism gave way to cognitive psychology in the early 1980s, teacher educators began to focus more on the ways in which teachers think rather than on the ways they behave. The idea that teaching is a complex, ill-structured activity became widely accepted and expert teachers were seen as having rich resources to draw on during instruction (Berliner, 1986). One implication for TPD was the idea that novice teachers could learn from studying the practice of more expert teachers including the thinking behind their practices. Subsequently, case-based pedagogy became very popular. Teacher educators expect working with cases can help teachers become accustomed to reflecting on teaching and to aid in the development of professional problem-solving strategies. In addition, cases also illustrate the perspective that teaching is complex and that teachers must manage multiple tensions simultaneously (Lampert, 1985). In short, case-based pedagogy is a good alternative for developing teachers in the cognitive domain. Coupled with the advances in computer technology and the ability to digitize video, we now see a plethora of studies making use of digital video for various TPD purposes, amongst which a focus on the cognitive domain is the most popular. We offer three recent examples with slightly different orientations.

Eilam and Poyas (2006) created a video and internet site; associated with it, they designed an intervention for student teachers to address the difficulties the complex classroom environment poses for teachers. The intervention emphasized implicit cognitive

processes as central to teaching-learning processes and the utilization of theoretical knowledge while making sense of the interrelations in complex situations. Following the intervention, the novices were found to exhibit a shift toward a cognitive rather than behavioral perspective; and they had improved ability to identify and interpret implicit and explicit factors and interrelations, which reflected their heightened awareness of the complexity of teaching. They also showed an enhanced capacity to link perceived teaching-learning processes to theoretical knowledge.

In our experience of training student teachers (Yung, Wong, Cheng, Hui, & Hodson, 2007), we used videos of two exemplary science lessons to elicit, develop and track their changing conceptions of good science teaching at three different points over a one-year teacher education programme. We found that the videos acted as an effective probe to elicit student teachers' conceptions and had significant impact on those conceptions at different stages. The experience extended student teachers' awareness of alternative teaching methods and approaches that they did not experience in their own schooling, broadened their awareness of different classroom situations, provided proof of existence of good practices and prompted them to reflect on their current conceptions of good science teaching.

Cognitive learning is also emphasized in TPD programmes for practicing teachers. Sherin and Han (2004) investigated the learning of four middle school mathematics teachers as they watched and discussed videotapes of their classrooms in video club meetings. Over a one-year period, discourse in the video clubs shifted from a primary focus on the teacher to increased attention to students' actions and ideas. Discussions of student thinking moved from simple restatements of students' ideas to detailed analyses of student thinking. Teachers also began to reframe their discussions of pedagogical issues in terms of student thinking. All these important changes were attributed to the development in teachers a 'professional vision' (p.179). According to Goodwin (1994), as people become part of a professional discipline, they develop particular ways of viewing the phenomena that are of interest to their

professional group. It implies that a good understanding of the discipline is necessary for developing a professional vision and, in this case, video clubs played a vital role in speeding up the process.

In sum, Sherin and Han (2004) characterized the learning occurred in the video club as the development of teacher's professional vision. The teachers learned to attend to particular kinds of events that had happened in classrooms and to reason about these events in particular ways. The concept of 'professional vision' surmounts other outlooks of cognitive learning adopted by different studies. It captures the four key elements of cognitive outcomes we wish to encompass in our TPD model using video, which are teachers' capability to identify particular classroom events, to link their practices to theoretical knowledge, to account for the reasons of adopting (or not adopting) certain strategies in new contexts, and to theorize their practices.

TPD targets within the affective domain

Compared to the cognitive and psychomotor domains, TPD programmes with an explicit focus on developing teachers in the affective domain are rare. There could be two reasons. First, teachers are more concerned with improving their skills and knowledge. Novice teachers' focus on survival skills is particularly prominent. They may not be aware of the importance of affective learning to their own professional growth and hence have undermined its value. Second, from the teacher educator and researcher perspective, many understand that teacher attitude is notoriously difficult to change, and requires interventions of sufficient vigor and long duration to effect change. Much resources and manpower are needed to run TPD programmes of this sort and hence there are little studies in this area. Below are a few examples, albeit affective outcomes were not a prime focus at the beginning of some of the projects (Incidentally, these are all studies of a longer duration).

For instance, after reviewing the same video several times at three stages, student

teachers in our studies had increased confidence to try new practices (Wong, Yung, Cheng, Lam, & Hodson, 2006; Yung et al., 2007). This boost in confidence was attributed to the 'proof of existence' (Black & Atkin, 1996) provided by the videos. That is, demonstration of existence of exemplary practices in normal classroom settings provided teachers with moral support that these could also work in their classroom settings. Similar findings can be observed in studies carried out for in-service teachers. The teachers who used video to reflect on their practice showed a significantly greater increase in their science teaching efficacy than those who did not use videos (McConnell et al., 2008).

In a one-year school-based TPD programme, a teacher with 14 years of teaching experience felt empowered in pursuing his ideals of science teaching after watching and 'resonating' with exemplary practices shown in our video workshops (Lo & Yung, 2009). This was in contrast to the experience of another novice teacher, who described his emotional state as "at the bottom of a very deep valley" after watching the same videos, for fear of not able to perform to the same standard. His identity as a competent teacher was eventually re-invigorated through a series of video-based lesson study[1] of his own lessons, in the process of which his practices were highly praised and recognized by his colleagues.

In summary, we believe that teacher attitudes and their value system can be changed by engaging them in video-mediated TPD activities, and teacher educators should not take teachers' affective learning lightly. They should not treat the affective outcomes as secondary to the cognitive ones, and/or leave them to happen by chance. Related to teachers' affective development is their social development (Bell & Gilbert, 1996).

TPD targets within the social domain

With the emergence of the situative perspective of learning (e.g. Anderson, Greeno, Reder, & Simon, 2000; Cobb & Bowers, 1999), there is a growing interest in studying TPD through such lens. Community building is advocated to be an essential feature for TPD programmes

(Putnam & Borko, 2000; Little, 2002). For learning to occur, teachers must become a member to gain access to resources from a community (Lave & Wenger, 1992, p.53), or form learning communities themselves. Within the community, teachers should have a sense of belonging, and be supportive, collaborative and respectful. As Wenger wrote about community of practice:

> "[it] requires *a strong bond* of communal competence along with *a deep respect* for the particularity of experience." (Wenger, 1998, p.214; emphases added by the present authors)

The bonding between the participants should come along with trust building in a community. As video recording encroaches into one's territories of classrooms, and creates visible impacts on students, teachers and the schools, the participants undergoing TPD must have a safe environment to share their videos, to receive critical comments on their teaching and to give comments on the others (Hall & Wright, 2007; Yung, 2003). Establishing trust does not necessarily mean more mindful language used in a group; rather it refers to building this environment conducive for TPD.

Few researchers actually describe the ways they promote community building in their projects. A unique example is provided by Borko et al. (2008). They documented in details their efforts to promote a supportive environment for TPD, and the ways in which teachers' conversations around video developed over a two-year period. Specifically, a summer institute was used to prepare teachers for establishing the communication norms including the appropriate attitudes and languages used in discussions, as well as a comfortable environment for the participants to share their views. As a result, the teachers formed a supporting community in which they talked respectfully and openly. Noteworthy is that the TPD facilitators distributed a copy of the article *'The New Heroes of Teaching'* (Hiebert, Gallimore & Stigler, 2003) to remind the participants that those who were willing to share their

classroom video were courageous. The teachers whose lessons were reviewed could receive critique, but radical comments should be avoided. This became part of the communication norms in the discussion about the video.

At the personal level, a supportive community is conducive for developing professional identity. This identity is not simply about teachers' knowledge and beliefs. It is built upon personal recognition of certain practices and the recognition of others within the community (Lave and Wenger, 1992). It is the 'professional philosophy, passions, commitments, ways of acting and interacting, values, and morals', which allows teachers to acquire the vision necessary for education reforms (Luehmann, 2007). This is also closely related to the 'professional vision' envisaged in the cognitive domain of our TPD model. An example of developing teachers' professional identity came from Maclean and White (2007). They examined ways in which student teachers identified themselves as professional teachers and how this identity was shaped by membership of a team comprising student teachers, mentor teachers and teacher educators. The project successfully created a collaborative team with shared talk and action in the planning of lessons and joint reflection on videos of their own teaching. The student teachers constructed a social identity as members of the teaching profession through interactions with experienced teachers. This occurred through the negotiation of shared evaluations of specific actions seen on the videos and also shared understandings of what counts as good teacher behaviour. These successful experiences in the social domain contributed to developing student teachers' image of themselves as professionals. That, in turn, benefited the student teachers by increasing their confidence, enthusiasm and professional learning.

The above studies show that social learning through the use of video in TPD is possible. As Bell and Gilbert (1996) point out, teachers have to understand the problem of remaining isolated within their classroom. They would not grow as professionals unless they are provoked to new ideas, and helped to adjust to the changes with social support. Incorporating

the social dimension of teacher learning will make our model more comprehensive and informative to guide planning and evaluating TPD programmes.

A summary of the emergent model

Our model highlights the four domains of learning outcomes which TPD using video can achieve and they are: psychomotor, cognitive, affective and social domains (Figure 2). We reckon these four aspects are inter-related and interplay with each other. For instance, knowledge gain in cognitive learning can lead to a boost in confidence and shaping of teachers' identity (affective learning), and vice versa. Moreover, building up a community of practice (in the social domain) can be a mean for supporting conversation among the participants and hence, assisting them to acquire the skills in teaching (psychomotor), develop multiple perspectives to analyze pedagogies (cognitive) and motivate them to implement practices in new contexts (affective). In sum, any attempts aiming for development in a particular domain may have a bearing on the development in other domains.

Figure 2. Learning outcomes of teacher professional development using video
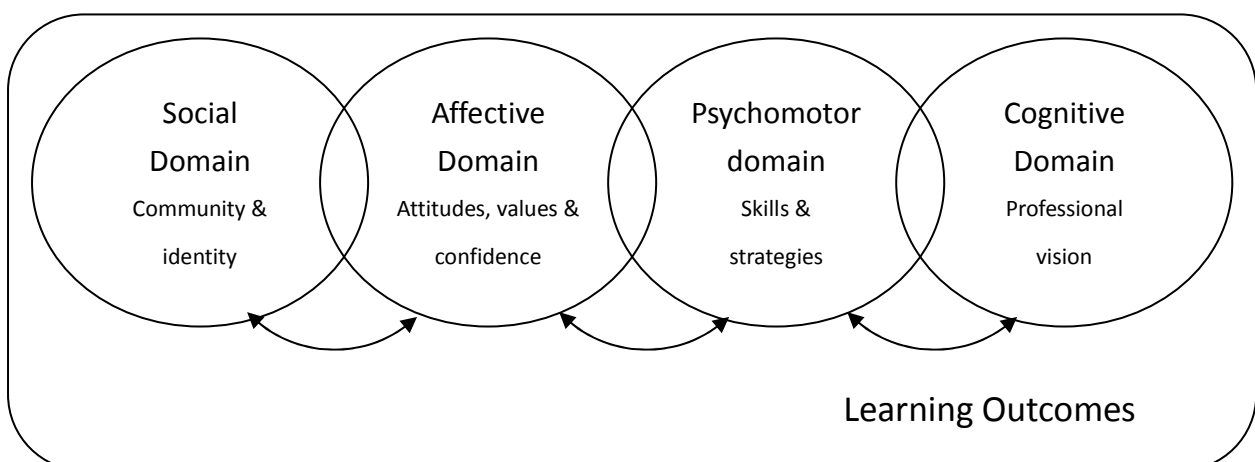
The current situation is that studies generally focus on only one or two domains, mostly cognitive and psychomotor. Little attention is given to the other two domains. Researchers usually value community building but they rarely intentionally build in mechanisms to enhance the social development. Affective learning also remains a secondary concern. By including these two aspects in our model, we wish to raise the awareness of teacher educators to focus on all the four domains of learning outcomes and support teacher learning accordingly.

The Means: Different ways of using video for TPD purposes

To be an effective tool for teacher learning, as cautioned by Brophy (2004), video must be selected with the curriculum goals in mind. Furthermore, the clips must be embedded within activities that are carefully planned to scaffold teachers' learning progress toward those goals. Based on literature review and our own experiences, we identify three effective means that can engage teachers in reviewing classroom videos for TPD purposes. They are engaging teachers in: (1) critical reflection, (2) meaningful comparison, and (3) productive discussion. In practice, multiple strategies are often used in a single TPD programme. For the sake of building our model, we shall examine the strategies one by one.

Engaging teachers in critical reflection

Reflection has been called the 'cornerstone of professional development' (Baird, 1992) and is a central element of many TPD programmes. Reviewing classroom videos provides opportunities for reflection. Videos provide multiple and repeated opportunities to re-play, analyze and re-analyze the same episode and provide opportunity to study the fast-paced, complicated world of classroom teaching at depth (Sherin, 2004). Involving teachers deliberately to analyze their own lesson via video can enable teachers to "step outside of the teaching moment" and closely examine teaching strategies in relation to student learning

(Loucks-Horsley, Love, Stiles, Mundry, & Hewson, 2003, p.205). Rosaen, Lundeberg, Fritzen and Terpstra (2008) investigated the extent and the ways video could help student teachers reflect on their teaching in a more complex manner than the time when they used written reflection tasks. Findings suggested that video-supported reflection encouraged the student teachers to write more specific (versus general) comments about their teaching than writing by memory recall, to shift the content of the reflections from a focus on classroom management in memory-based reflections to emphasizing instruction when video was available, and to focus less on themselves and more on children when they reflected on video clips of their teaching. All student teachers rated video-based reflection and analysis of their practice as being more accurate and useful than memory-based written reflection since video provided concrete evidence and a more tangible view of teaching. These findings indicate the potential of using video to engage teachers in reflection of their practices. Other supportive findings follow.

In the study of Hewitt, Pedretti, Bencze, Vaillancourt and Yoon (2003), a challenging video episode was shown to student teachers. They were required to write down their immediate response to the teaching situation as if they were the teacher-in-video; and then discuss with their peers. After that, they wrote down their refined response in the reflection sheet. In brief, this group of teacher educators hoped to increase student teachers' awareness of their own reactions to teaching situations, and highlighted the benefits of sharing one's reactions with fellow student teachers. As the participants were required to make decision on the spot, the researchers coined this as a kind of reflection-in-action.

This differs from other studies where teachers engage in reflection-on-action. In this case, there is not a time limit imposing on the teachers' thinking and reflection. They can reflect on the teaching episode at any time after the event was over for unlimited times and duration. In some cases, teachers are given specific foci to reflect on each time they revisit the episode again. For example, Santagata, Zannoni and Stigler (2007) asked the student

teachers to watch the video three times, each time focusing on a different aspect of the lesson, namely, (1) parts of the lesson and learning goals, (2) students' thinking and learning, and (3) alternative teaching strategies. Indeed, it is common for studies to provide guidance, prompting questions or specific foci to facilitate teachers' reflection on the video (for example, Sherin & van Es, 2005; Wong et al., 2006).

Some studies involve teachers in reviewing, selecting and editing of their own videos (see for example, Armstrong & Curran, 2006; Beck, King, & Marshall, 2002; Maclean & White, 2007), which stimulates teachers to reflect on their teaching several times. In the study of Maclean and White (2007), participants first reviewed and reflected individually on an unedited video of their teaching immediately after the lessons and selected excerpts to be included in an edited version that was going to be presented in a group meeting for discussion. In the group discussion, they reflected collaboratively with the group. This viewing and editing creates multiple layers of reflection.

In our case (Yung et al., 2007), student teachers were asked to review and reflect on the same videos on different occasions at three points in time of their teacher education programme. Such longitudinal and progressive reflection on the *same* set of videos aimed to elicit and track the participants' changing conceptions of good science teaching. The videos stimulated student teachers to reflect on the quality of teaching they experienced in their own schooling, which gradually helped to promote reformulation of their conceptions of good and bad science teaching. The student teachers recognized that reviewing the *same* videos at different times was a crucial element in facilitating their reflection on their changing conceptions. In brief, inclusion of progressive and longitudinal reflection-on-action is useful for achieving TPD learning outcomes that need a longer time to develop.

The above examples suggest that video has a great potential of engaging teachers in reflection of their practice, as nicely summarized by Tan and Towndrow (2009), "Technology can serve as a source of learning and development but its value as a pedagogical amplifier is

only manifested when it is coupled with reflection in and on practice" (p.66). We would add that the use of video as a pedagogical amplifier could be enhanced only if the reflection undertaken by teachers is *critical* enough.

According to Rodgers (2002), reflection is a meaning-making process that moves a learner from one experience into the next, with deeper understanding of its relationships with and connections to other experiences and ideas. Korthagen (2005) highlights that "the essence of reflection is bringing the unconscious aspects of teaching into conscious awareness, so that people become more sensitive to important aspects of educational situation". Moving from this point, teachers have to 'problematize the unproblematic' situations, experiment and explore new resolutions and seek for challenges (Tsui, 2003). In other words, they have to move from being practitioners to professionals by finding out the theories and rationales behind old and new practices, make appropriate contextual adaptations and justify the expected outcomes. This involves complex cognitive processes such as observing, reasoning, rationalizing, theorizing and modifying strategies. All these embrace the qualities of critical reflection that we are referring to in our model. These are important attributes that TPD designers should bear in mind in designing video-mediated TPD activities.

Engaging teachers in meaningful comparison

Many studies offer opportunities for teachers to *compare* videos from different sources (e.g. publicly available versus teachers' own video – see Lundeberg et al., 2008), and of teachers teaching in different contexts (e.g. high abilities versus low abilities students - see Yung et al., 2007), etc. But seldom do these studies draw readers' attention to the importance of engaging teachers in making *comparison* as a tool for *meaningful* teacher learning to take place. Here, it suffices an explanation of what we mean by meaningful comparison.

The word *"meaning"* has two connotations in our model. Firstly, it refers to the notion

that teachers will find their learning more *meaningful* when it is embedded in their practice (Lieberman, 1996). This is in line with the central tenet of the situated learning perspective (e.g. Lave & Wenger, 1992; Rogoff, 1990), namely, the contexts and activities in which people learn become a fundamental part of what they learn. Though teachers may not be actually teaching the class, by watching and comparing different videos, teachers can gain access to different classroom situations and a wide variety of instructional strategies, curricula, as well as classroom cultures that they may not have encountered in person; and yet they would still find these comparisons meaningful as they are situated in authentic classroom practices.

Secondly, through watching and comparing videos, teachers will have the opportunity to *make sense* of the teaching practice demonstrated in the videos. Teachers will have the opportunity to develop the ability of noticing and interpreting what is happening in their own and other's classroom. As Berliner (1994) suggests that when experienced teachers assess the classroom situations, they will be able to recognize *meaningful* patterns in what they observe. Likewise, Rodgers (2002) also recognizes when teachers notice something important in classroom interaction, they will propose a *meaning* to that situation. van Es and Sherin (2002) even explored what it means for teachers to identify *meaningful* events. They put forward the importance of 'learning to notice' while teachers are learning in video clubs (Sherin & Han, 2004; van Es & Sherin, 2008). In summary, we would like to define 'meaningful comparison' at a level higher than just making teachers feel linked to the video. We envisage that meaningful comparison should result in ample ideas for critical reflection on practices and/or ideas to be debated among teachers. Below we review studies that embody our notion of meaningful comparison.

Copeland and Decker (1996) conducted one of the earliest studies on the effect of watching video case in the development of meaning making in pre-service teachers. In order to study their meaning making process, the student teachers were asked to view, analyze and

compose written statements on the video case in groups. This group discussion, as pointed out by the researchers, provided a platform for the student teachers to *compare* their own meaning making with others, and hence fostered their consideration of alternate meanings on the video vignette. It was reported that over one-third of the topics that the student teachers discussed in the different groups were adopted, transformed or created by the respondents in describing their own meaning making of the video case three weeks after the group discussion. However, how the comparison of own and others' meanings of the video case had benefited the respondents was not stressed.

Teachers in Sherin and Han's (2004) study were purposely asked to compare the different mathematics ideas presented by two students as shown in a video. The intention was to draw teachers' attention to student thinking. At the end of their seventh meetings, with this kind of *meaning-making* comparison of what is happening in the videos, teachers' discussion in the video club had shifted from a primary focus on the teacher performance to increased attention to students' actions and ideas. Discussions of student thinking had also moved from simple restatements of students' ideas to detailed analyses of student thinking. Later, Eilam and Poyas (2006) also demonstrated the effectiveness of asking student teachers to compare video clips from different classroom contexts in developing their meaning-making abilities.

In one of our studies, (Yung et al., 2007), we embraced the notion of meaningful comparison at two levels. At the first level, we asked the student teachers to watch the same set of exemplary videos on three separate occasions spaced out in a year. As revealed in the interview excerpts, the student teachers did compare the actions of the teachers-in-videos with their own schooling experience, their own experiences during the practicum. They also compared the teaching styles, attitudes and approaches of the two teachers-in-videos. At the second level, upon graduation from the programme, we asked the student teachers to compare the comments they had made on the videos on the three separate occasions and to reflect on any changes they noticed. Student teachers found this a meaningful comparison and a useful

way to track changes in their own conceptions of good science teaching.

Clearly, as evident from above, video provides an opportunity to open up teachers' eyes of seeing alternative teaching strategies. Through viewing videos and making *meaningful comparison*, teachers can gain access to (and making sense of) a wide variety of instructional strategies, curricula and classroom cultures that they cannot obtain through other means. Hence, the notion of *meaningful comparison* should be one of the key considerations in the design of video-mediated TPD programmes. It would have an important bearing on the kind of videos to be selected in relation to the nature of participants, as well as the intended learning outcomes. There is currently a lack of studies with an explicit focus in this area.

Engaging teachers in productive discussion

Due to the nature of work, teachers' patterns of thought and action may become routine. Engaging teachers in discussion with peers enables teachers to listen to opinions from different perspectives, and hence to experience things in new ways. As revealed earlier, peer-discussion of videos has a positive impact on the meaning-making process of student teachers (Copeland & Decker, 1996). In general, teachers perceive discussions with colleagues in collaborative settings as valuable for their learning and improvement of teaching practices (e.g. Borko, 2004). What follows is our analysis of the various means employed to facilitate discussion among participants of video-mediated TPD programmes.

We broadly divide the means into three categories: technological means, task-oriented means and personnel means. Technological means refer to those that capitalize on advances in computer technologies to find ways of facilitating peer discussion. For example, So et al. (2009) created an online platform where teachers can access a video database for retrieval of shared videos, annotate and discuss the stored videos. Many studies (e.g. Lee & Wu, 2006; Schrader et al., 2003; Sorensen, Newton, & Harrison, 2006) embed the videos in hypermedia environment together with other related materials of the videotaped lessons, such as lesson

plans, samples of student work, and comments from the teacher or educators. The aim is to facilitate more productive discussion among the participants. However, it is not unproblematic to ask teachers to work online as a group as their connection can be loose. It is contingent on developing protocols for involving teachers to work collaboratively in a virtual environment (Newton, 2007).

The task-oriented means refer to those tasks that are designed for completion by TPD participants in order to prepare them for a productive discussion at a later stage. The personnel means refer to the appointment of personnel who will play a facilitating role during the discussion. Both of these are human-related in the sense that the first one is akin to designing a curriculum aiming for a productive discussion, and the second one is like appointing skilled personnel to implement the curriculum. In both cases, expertise knowledge and skills are required.

Provision of the first kind includes setting preparatory tasks that have to be completed before group discussion. This often entails in-depth analyses of the video, which can be open-ended or guided by a theoretical framework. The guidance can be as general as 'to identify special points in the clip' (e.g. Copeland & Decker, 1996; Sherin & van Es, 2005), 'to identify the features of good science teaching' (e.g. Wong et al., 2006), or as a 'conference agenda' (e.g. Sharpe et al., 2003). Alternatively, a detailed analytic frame may be offered (e.g. Borko et al., 2008; Beck, King, & Marshall, 2002; Schrader et al., 2003; Sherin et al., 2009). In general, the latter approach is found to be more effective in promoting discussion among the participants, and subsequently improving their ability to identify, interpret and analyze evidence of effective teaching.

Two major personnel means are identified. The first one is inclusion of the teacher-in-video in the discussion, and a facilitator in the second. Both aim at assisting teachers in gaining more perspectives and hence more productive discussion. Koc, Peker and Osmanoglu (2009) provide evidence of the positive impact on the inclusion of the video case

teacher in their online discussion forum. The case teacher provided other participating teachers the rationale of the teaching practice in the video so that they could verify their interpretation of the video and thus, enhanced the depth and richness of the topics discussed. Nonetheless it was acknowledged that such arrangement could have adversely affected the participants' contribution to the discussion because they might not have felt as comfortable as when the case teacher was not in the forum. Some participants might have refrained from putting their ideas into text.

A commonly used strategy to enhance video-mediated discussions is the inclusion of a facilitator, usually a knowledgeable other such as university educator (e.g. Borko et al., 2008; Santagata, 2009; Sherin & Han 2004; Sherin & van Es, 2005; Sherin & van Es, 2009). This can avoid superficial comments that may constrain progression of the discussion (Copeland & Decker, 1996). The facilitator is expected to be able to set up and moderate the discussion, to describe what the teachers should look for in the video clip, help them to make sense of the classroom events, and get teachers' attention focused on the topic under discussion. Seeing the important role of facilitator, some studies put premium on the academic background of the facilitator as well as their experiences in video-mediated TPD programmes. In addition, providing facilitators with a detailed outline of the learning outcomes can help them to conduct a productive discussion. As Santagata (2009) put it, "… [This] assisted the facilitators in leading the discussion and in funneling teachers' comments toward better understanding of the target mathematical concepts and of ways students can be assisted in developing more sophisticated understandings". Many studies might have underestimated the important role of facilitator and the challenges imposed on them. This is currently an under-researched area.

In sum, 'productive discussion' is an important consideration in the design of video-mediated TPD programs. Technological, task-oriented and personnel means can be used to enhance the quality of discussion. In our model, we define productive discussion as a

deep engagement in which teachers analyze the classroom video with different perspectives, and make sense of the discussion points collaboratively. In order to make discussion productive, a trusting and supportive environment is crucial. In connection to this, the importance of an experienced, skilled and knowledgeable facilitator to set the stage, guide and moderate the discussions and build communication norms should not be ignored.

A summary of the means to achieve the four learning outcomes

We have described three major means of using video to achieve the TPD learning outcomes: critical reflection, meaningful comparison and productive discussion. They are not independent entities; rather they can have profound synergies when used together in different combinations. For example, teachers can be provided with two contrasting video episodes to review individually prior to a face-to-face meeting. This can elicit meaningful comparison and critical reflection at the individual level, which in turn will lead to productive discussion at the community level during the face-to-face meeting with other teachers. This may give further foods of thought to ignite another chain of critical reflection at the individual level. In other words, the different means interplay with each other as shown by the arrows in Figure 3. We also place facilitators in the midst of the means to indicate their key role in the process.

Figure 3. The three means used to achieve the learning outcomes
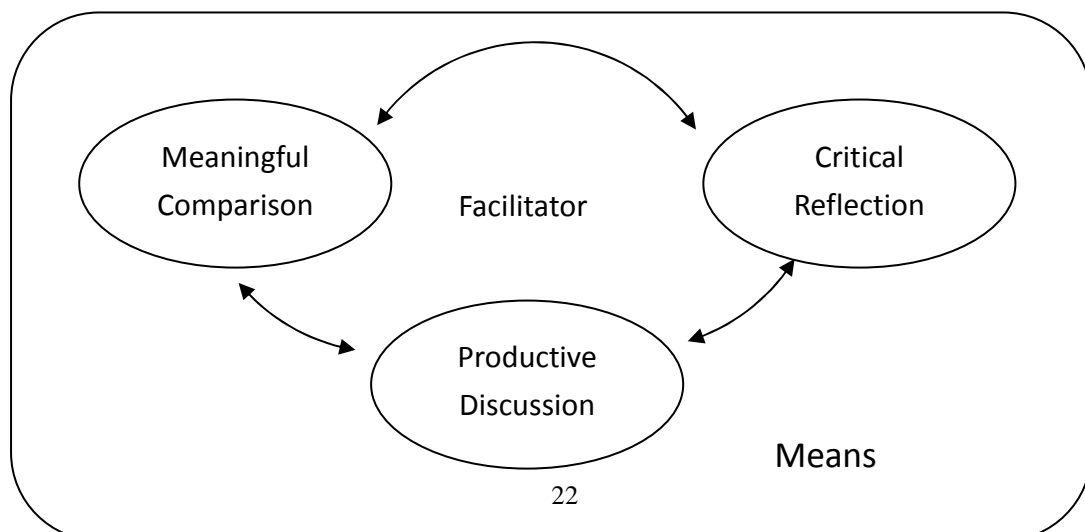
A Crucial Step: Video selection

It is not enough simply to take video recordings and use them for TPD purposes. Videos need to go through a selection process to ensure fitness for purpose. This is a crucial process that needs to take into consideration a multitude of interacting variables as shown in our model (Figure 4).

Figure 4. Model of effective use of video for teacher professional development
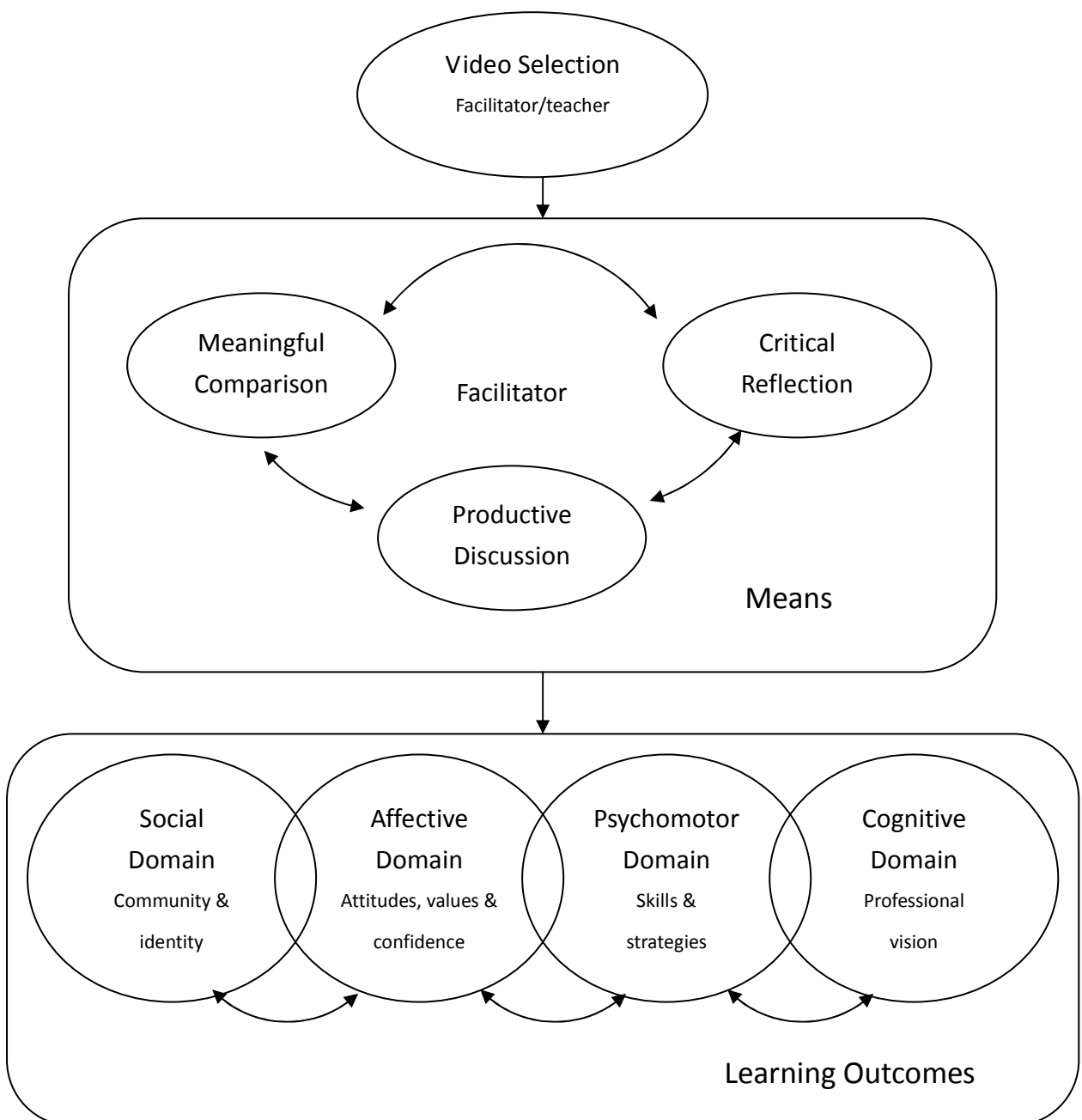
On the one hand, Hall and Wright (2007) suggest that some sort of verification process is needed to determine the quality, accuracy and reliability of professional knowledge shown in the videos. On the other hand, Borko et al. (2008) argue that there is little agreement as to what actually constitutes high quality professional development. Set against this background, we find our model particularly useful. While it lays down a holistic framework to guide TPD designers in selection of videos, it does not prescribe any specific criteria that they must adhere to. Educators can develop their own programmes according to their purposes in mind without losing sight of the alternatives.

An important question remains regarding the selection of videos: Who is/are in the best position to undertake this crucial job? Based on the results of a survey on student teachers' views on the usefulness of video for their professional development, Kurz, Batarelo, & Middleton (2009) argue that the video should address teachers' beliefs and concerns in order to be effective. For this reason, many argue (e.g. Santagata, 2005) that teachers' participation to produce video clips for their own consumption is important. Lundeberg and her colleagues (2008) conducted an interesting study which explicitly asked teachers to compare different kinds of video: the TIMSS[2] videos, the teachers' own videos and videos of teachers' colleagues. In the first phrase of the study, teachers were asked to analyze TIMSS video cases. After that, teachers videotaped their own practices and met monthly in small groups. In the group meetings, teachers presented and discussed their own video cases with their peers. Teachers reported that creating own videos and discussing those videos had a greater impact on their practice than analyzing TIMSS videos. Comparing own teaching to their peer's practice provide a platform for them to gain new perspectives into their own practice by vividly experiencing peers' struggles, and by seeing different ideas for their own teaching. Similar findings were obtained in Maclean and White's (2007) study where the student teachers and mentor teachers viewed the unedited video of their teaching and selected excerpts to be included in an edited version presented to the larger team. This initial viewing

and editing gave teachers agency in controlling the aspects of their teaching to be discussed and created multiple layers of reflection.

While sharing the view that video from teachers' own classroom lessons are likely to be a motivating source for discussion, Sherin et al. (2009) see the downside of letting teachers selecting videos on their own. This would limit the TPD designer's ability to select videos that can help achieve the intended learning outcomes in pre-established ways. Arguably, the TPD designers, who are knowledgeable of the intended learning outcomes as well as how they would be affected by the multitude of factors described in our model, should be involved in the process as far as possible, at least in collaboration with the teachers in one form or another. An example is found in the study of Armstrong and Curran (2006). They invited the teachers to select episodes from the unedited footage of their own lessons. Ample time was given so that teachers could review their teaching with multiple lenses. Subsequently the teachers and researchers came together to co-analyze the selection and to construct new knowledge. The process was repeated for several times to build up the collaboration between the two parties. Hennessy and Deaney (2009) adopted similar strategies to integrate multiple teacher and researcher perspectives in their co-construction of knowledge through in-depth analysis of teachers' own videos. Our own experience to jointly work with the teachers to select video is coherent with the cases described above. Such collaboration does not only establish connection between teachers' classroom experience and the video used, it also delivers a message that the researchers respect and welcome teachers' contribution. This can be important to establish communication norms and to build trust in a learning community.

Conclusion

Inspired by the increasing interest in the use of video for TPD purposes, the present paper asked a long-neglected, but crucial question: What are the factors that TPD designers need to consider in selecting videos for their programme? We answered the question by reviewing the

literature, identified and assembled the factors into a model of effective use of video for teacher professional development as shown in Figure 4. In the model, the interplay between the factors is stressed, in particular, the synergies between critical reflection, meaningful comparison and productive discussion. The crucial role of the facilitator is highlighted. Video selection as a crucial process is discussed. As such, the model should be a useful heuristic device for TPD designers to develop video-mediated curricula. It also provides a holistic theoretical framework for guiding future research in the field. For instance, the areas in video selection, role of facilitator, meaningful comparison, outcomes in the affective and social domains are relatively under-researched; findings of which will help to refine the model. In sum, our effort represents only an initial step towards a model of effective use of video for teacher professional development.

Notes

1. Lesson study includes iterative cycles of studying curriculum, setting learning goals, planning and conducting the lessons, as well as reflecting upon the classroom experience. In the video-based lesson study, participating teachers jointly selected a topic and planned a lesson. They then taught the lesson which was videotaped. The teachers reflected on the video individually and then selected clips for sharing with the researchers as facilitators.

2. TIMSS (Trends in International Mathematics and Science Study) is an international comparative assessment of the mathematics and science knowledge of fourth- and eighth-grade students around the world. Its associated video studies examined national samples of 8th grade mathematics lessons from countries including Germany, Japan, United States, Australia, the Czech Republic, Hong Kong, Netherlands and Switzerland. The sampled lessons were videotaped; and sample lessons from each country are made available publicly. The TIMSS videos referred to in Lundeberg et al's (2008) study fall into this category.

References

Admiraal, W., Veen, W., Korthagen, F., Lockhorst, D., Wubbels, T., Hernadez, F., Fonollosa, M., Grisos, A., McShea, J., Bennett, N., Davis, N., Jennings, S., Gudmundsdottir, S., & Hoel, T. (1999). Tele-guidance to develop reflective practice: Experiences in four teacher education programs across Europe. *Journal of Information Technology for Teacher Education*, *8*(1), 71–88.

Allen, D. & Ryan, K. (1969). *Microteaching reading*. Massachusetts: Addison-Wesley Publishing Company.

Anderson, J., Greeno, J., Reder, L., & Simon, H. (2000). Perspectives on Learning, Thinking and Activity, *Educational Researcher*, *29*(4), 11–13.

Armstrong, V., & Curran, S. (2006). Developing a collaborative model of research using digital video. *Computers & Education, 46*(3), 336–347.

Baird, J.R. (1992). Collaborative reflection, systematice enquiry, better teaching. In T. Russell & H. Munby (Eds.), *Teachers and teaching: From classroom to reflection*. New York: Falmer Press.

Beck, R.J., King, A., & Marshall, S.K. (2002). Effects of video case construction on preservice teachers' observations of teaching. *The Journal of Experimental Education, 70*(4), 345.

Beliner, D.C. (1986). In Pursuit of the Expert Pedagogue. *Educational Researcher*, 15(5), 5-13.

Berliner, D.C. (1994). Expertise: The wonder of exemplary performances. In J.M. Mangier & C.C. Block (Eds.), *Creating powerful thinking in teachers and students: Diverse perspectives* (pp. 161-186). Fort Worth, TX: Holt, Rinehart, & Winston.

Bell, B. & Gilbert, J. (1996). *Teacher development: a model from science education.* London: Falmer Press.

Black, P. & Atkin, J.A. (1996). *Changing the subject: Innovations in science, mathematics and*

technology education. London: Routledge.

Borko, H. (2004). Professional Development and Teacher Learning: Mapping the Terrain. *Educational Researcher, 33*(8), 3–15.

Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M.E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teacher and Teacher Education, 24*(2), 417–436.

Brophy, J. (2004). Introduction. In J. Brophy (Ed.), *Using video in teacher education.* Amsterdam: JAI.

Cobb, P. & Bowers, J. (1999). Cognitive and Situated Learning Perspectives in Theory and Practice. *Educational Researcher, 28*(2), 4–15.

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

Eilam, B. & Poyas, Y. (2006). Promoting awareness of the characteristics of classroom's complexity: A course curriculum in teacher education. *Teaching & Teacher Education, 22*(3), 337–351.

Frederiksen, J.R. (1992). *Learning to "see": Scoring video portfolios or "beyond the hunter-gatherer in performance assessment.* Paper presented at the Annual Meeting of the American Educational Research Association, San Francisco.

Goodwin, C. (1994). Professional Vision. *American Anthropologist*, *96*(3), 606–633.

Graven, M. (2004). Investigating Mathematics teacher learning within an in-service community of practice: The centrality of confidence. *Educational Studies in Mathematics, 57*, 177–211.

Greenburg, J. (1971). Videotaping and teacher preparation. *Journal of Health, Physical Education Recreation*, *42*(4), 32.

Guskey, T.R. (2000). *Evaluating professional development*. Thousand Oaks, Calif.: Corwin Press.

Hall, I., & Wright, D. (2007). *Literature Review of the use of Video as a resource for professional development of mathematics teachers*. Newcastle upon Tyne: The Research Centre for Learning and Teaching (RCfLaT), School of Education, Newcastle University.

Hennessy, S., & Deaney, R. (2009). 'Intermediate theory' building: Integrating multiple teacher and researcher perspectives through in-depth video analysis of pedagogic strategies. *Teachers College Record, 111*(7), 1753-1795.

Hewitt, J., Pedretti, E., Bencze, L., Vaillancourt, B. D., & Yoon, S. (2003). New applications for multimedia cases: promoting reflective practice in preservice taecher education. *Journal of Technology and Teacher Education, 11*(4), 483–500.

Hiebert, J., Gallimore, R., & Stigler, J. W. (2003). The New Heroes of Teaching. *Education Week, 23*(10), 42,56.

Jensen, R.A., Shepston, T.J., Connor, K., & Killmer, N. (1994). *Fear of the Known: Using Audio-Visual Technology as a Tool for Reflection in Teacher Education*. Paper presented at the 74th Annual Meeting of the Association of Teacher Educators.

Koc, Y., Peker, D., & Osmanoglu, A. (2009). Supporting teacher professional development through online video case study discussions: An assemblage of preservice and inservice teachers and the case teacher. *Teaching and Teacher Education, 25,* 1158–1168.

Koorland, M., Tuchman, B., Wallat, C., Long, B., Thomson, S., & Silverman, M. (1985). A pilot evaluation of the PREED program: An innovative student–teacher supervision model. *Educational Technology, 25*(10), 45–47.

Korthagen, F.A.J. (2005). Practice, Theory, and Person in Lifelong Professional Learning. In D. Beijaard, P.C. Meijer, G. Morine-Dershimer & H. Tillema (Eds.), *Teacher Professional Development in Changing Conditions* (pp. 79–94). Netherlands: Springer.

Kurz, T.L., Batarelo, I, & Middleton, J.A. (2009). Examining elementary preservice teachers' perspectives concerning curriculum themes for video case integration. *Education Tech Research Dev, 57,* 461–485.

Lampert, M. (1985). When the Problem Is Not the Question and the Solution Is Not the Answer: Mathematical Knowing and Teaching. *American Educational Research Journal*, 27(1), 29-63.

Lave, J., & Wenger, E. (1992). *Situated learning : legitimate peripheral participation* Cambridge: Cambridge University Press.

Lee, G.C. & Wu, C.C. (2006). Enhance the teaching experience of pre-service teachers through use of videos in web-based CMC. *Innovations in Education and Teaching International, 43*(4), 369–380.

Lieberman, A. (1996). Practices that support teacher development: transforming conceptions of professional learning. In M.W. McLaughlin & I. Oberman (Eds.), *Teacher Learning: New Policies, New Practices* (pp. 185-201). New York: Teachers College Press.

Little, J.W. (2002). Locating learning in teachers' communities of practice: opening up problems of analysis in records of everyday work. *Teaching and Teacher Education*, 18(8), 917-946.

Lo, F.Y. & Yung, B.H.W. (2009). *Teachers' Affective Learning in Teacher Development Activities Using Classroom Videos as the Mediating Artifact*. Paper presented at the European Science Education Research Association (ESERA) Annual Conference 2009.

Loucks-Horsley, S., Love, N., Stiles, K.E., Mundry, S.E., & Hewson, P.W. (2003). *Designing professional development for teachers of science and mathematics* (2nd ed.). Thousand Oaks, Calif.: Corwin Press.

Luehmann, A.L. (2007). Identity Development as a Lens to Science Teacher Preparation. *Science Education*, 91(5), 822-839.

Lundeberg, M., Koehler, M. J., Zhang, M., Karunaratne, S., McConnell, T.J., & Eberhardt, J. (2008). *"It's like a mirror in my face": Using video-analysis in learning communities of science teachers to foster reflection on teaching dilemmas*. Paper presented at the annual meeting of the American Educational Research Association as part of a symposium on High Tech High Touch: Creating Discourse Communities Around Video Cases in Literacy, Science and Mathematics.

Maclean, R., & White, S. (2007). Video reflection and the formation of teacher identity in a team of pre-service and experienced teachers. *Reflective Practice, 8*(1), 47–60.

McConnell, T.J., Lundeberg, M.A., Koehler, M.J., Urban-Lurain, M., Zhang, T., Mikeska, J., Parker, J., Zhang, M., & Eberhardt, J. (2008). *Video-based Teacher Reflection – What is the Real Effect on Reflections of Inservice Teachers?* Paper presented at the 2008 International Conference of the Association of Science Teacher Educators

Newton, L.R. (2007). Supporting Teachers' Professional Development through ICT: Reflection on two cases. In A. Tatnall, T., Okamoto, & A. Visscher (Eds.), *IFIP International Federation for Information Processing, Volume 230, Knowledge Management for Educational Innovation*, 43-51. Boston: Springer.

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.

Rodgers, C. (2002). Defining Reflection: Another Look at John Dewey and Reflective Thinking. *Teachers College Record, 104*(4), 842–866.

Rogoff, B. (1990). *Apprenticeship in thinking: cognitive development in social context.* New York: Oxford University Press.

Rosaen, C.L., Lundeberg, M., Cooper, M., Fritzen, A., & Terpstra, M. (2008). Noticing Noticing: How Does Investigation of Video Records Change How Teachers Reflect on Their Experiences? *Journal of Teacher Education, 59*(4), 347-360.

Santagata, R. (2005). Practices and beliefs in mistake-handling activities: A video study of

Italian and US mathematics lessons. *Teaching and Teacher Education, 21,* 491–508.

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., Zannoni, C., & Stigler, J.W. (2007). The role of lesson analysis in pre-service teacher education: an empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education, 10,* 123–140.

Schrader, P.G., Leu, D.J., Jr., Kinzer, C.K., Ataya, R., Teale, W.H., Labbo, L.D., & Cammack, D. (2003). Using Internet Delivered Video Cases, To Support Pre-Service Teachers' Understanding of Effective Early Literacy Instruction: An Exploratory Study. *Instructional Science, 31*(4–5), 317–340.

Sharpe, L., Hu, C., Crawford, L., Gopinathan, S., Khine, M.S., Moo, S.N., & Wong, A. (2003). Enhancing multipoint desktop video conferencing (MDVC) with lesson video clips: recent developments in pre-service teaching practice in Singapore. *Teaching and Teacher Education, 19*(5): 529–541.

Sherin, M.G. (2004). New perspectives on the role of video on teacher education. In J. Brophy (Ed.), *Using Video in Teacher Education* (pp. 1–27). Amsterdam: Elsevier.

Sherin, M.G. & Han, S.Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education, 20*(2), 163.

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.

Sherin, M.G. & van Es, E.A. (2005). Using Video to Support Teachers' Ability to Notice Classroom Interactions. *Journal of Technology and Teacher Education, 13*(3), 475–491.

Sherin, M.G. & van Es, E.A. (2009). Effects of Video Club Participation on Teachers'

Professional Vision. *Journal of Teacher Education, 60*(1), 20–37.

So, W.W.M., Pow, J.W.C., & Hung, V.H.K. (2009). The interactive use of a video database in teacher education: Creating a knowledge base for teaching through a learning community. *Computers & Education, 53,* 775–786.

Sorensen, P.D., Newton, L.R. & Harrison, C. (2006). *The Professional Development of Teachers through Interaction with Digital Video.* Paper presented at the British Educational Research Association (BERA) Annual Conference 2006.

Tan, A.L. & Towndrow, P.A. (2009). Catalyzing student-teacher interactions and teacher learning in science practical formative assessment with digital video technology. *Teaching and Teacher Education, 25*(1), 61–67.

Tsui, A.B.M. (2003). *Understanding Expertise in Teaching: Case Studies of ESL Teachers.* Cambridge: Cambridge University Press.

van Es, E.A. & Sherin, M.G. (2002). Learning To Notice: Scaffolding New Teachers' Interpretations of Classroom Interactions. *Journal of Technology and Teacher Education, 10*(4), 571–596.

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*(2), 244–276.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.

Wong, S.L., Yung, B.H.W., Cheng, M.W., Lam, K.L., & Hodson, D. (2006). Setting the Stage for Developing Pre-service Teachers' Conceptions of Good Science Teaching: The role of classroom videos. *International Journal of Science Education, 28*(1), 1–24.

Yung, B.H.W. (2003). Are we looking for perfect? Should we or could we? What is the attitude? Teacher professional development through web-based videos of exemplary teaching. *Hong Kong Science Teachers' Journal, 21*(1), 20-31.

Yung, B.H.W, Wong, S.L., Cheng, M.W., Hui, C.S., & Hodson, D. (2007). Tracking

Pre-service Teachers' Changing Conceptions of Good Science Teaching: The Role of Progressive Reflection with the Same Video. *Research in Science Education, 37*(3), 239–259.