FACILITATING REFLECTION AND ACTION: THE POSSIBLE CONTRIBUTION OF VIDEO TO MATHEMATICS TEACHER EDUCATION

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ABSTRACT

In the Interconnected Model of Teacher Professional Growth (Clarke & Hollingsworth, 2002), change in teacher beliefs, knowledge and practice is mediated by either enaction or reflection. The stimulus for change can be provided by an external source such as a professional development program or it can result from the teacher's inevitable classroom experimentation and reflection on the consequences of that experimentation. This paper explores the role that video can play in catalysing change and facilitating teacher reflection. In particular, we examine: (i) international research employing video and the capacity of such research to inform practice and stimulate teacher reflection in both pre-service and in-service settings; (ii) the use of video in professional development programs and the choice between exemplary and problematic practice as catalysts for teacher reflection in both pre-service and in-service programs; and (iii) teacher agency and the catalytic role of video in supporting teachers' reflection on their own practice, through the use of video as the communicative medium to sustain a professional community of reflective practitioners.

KEY WORDS

Mathematics Teacher education; Reflection; Action; Video.

Facilitating Reflection and Action: The Possible Contribution of Video to Mathematics Teacher Education

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INTRODUCTION

Ideas of «teacher change» are open to multiple interpretations, and each interpretation can be associated with a particular perspective on teacher professional development. Clarke and Hollingsworth (1994) described six perspectives of teacher change:

- Change as training – change is something that is done to teachers; that is, teachers are «changed»
- Change as adaptation – teachers «change» in response to something; they adapt their practices to changed conditions
- Change as personal development – teachers «seek to change» in an attempt to improve their performance or develop additional skills or strategies
- Change as local reform – teachers «change something» for reasons of personal growth
- Change as systemic restructuring – teachers enact the «change policies» of the system
- Change as growth or learning – teachers «change inevitably through professional activity»; teachers are themselves learners who work in a learning community

It should be noted that these alternative perspectives on change are not mutually exclusive, and that many are in fact interrelated. Recent decades have witnessed a shift in conceptions of teacher change from professional development programs designed to «change teachers» to programs designed to facilitate teacher professional learning (Clarke & Hollingsworth, 1994, 2002; Fullan & Stiegelbauer 1991; Guskey, 1986; Hall & Loucks, 1977; Johnson, 1996). The key shift is one of agency: from programs that change teachers to teachers as active learners shaping their professional growth through reflective participation in professional development programs and in practice. Recognition of the need to contextualize teaching and teacher development has led to the advocacy of approaches to professional development that employ cases, including video cases (Clarke & Hollingsworth, 2000), as a means to situate the professional development of teachers in realistic contexts. This contextualization of teaching was also advocated in proposals for the «authentic» assessment of teaching (Darling-Hammond & Snyder, 2000).

Fundamental to 'new' perspectives on teacher change and teacher professional development that have learning as their core are views of teachers as learners and schools as learning communities. In this paper, we examine video as a medium for facilitating both teacher reflection and teacher action and thereby as a key tool for the promotion of teacher learning and teacher professional growth. In particular, we examine: (i) international research employing video and the capacity of such research to inform practice in both pre-service and in-service settings; (ii) the use of video in professional development programs and the choice between exemplary and problematic practice as catalysts for teacher reflection in both pre-service and in-service programs; and (iii) teacher agency and the catalytic role of video in supporting teachers' reflection on their own practice, through the use of video as the communicative medium to sustain a professional community of reflective practitioners. Specific research projects provide the examples of each of the three roles.

THE INTERCONNECTED MODEL OF TEACHER PROFESSIONAL GROWTH

Professional growth is an inevitable and continuing process of learning. By acknowledging professional growth as a form of learning, we become inheri-

tors of a substantial body of learning theory and research. The application of contemporary learning theory to the development of programs to support teacher professional growth has been ironically infrequent. In particular, models of teacher professional development have not matched the complexity of the process we seek to promote. Clarke and Hollingsworth (2002) outlined an empirically grounded model of professional growth that incorporated key features of contemporary learning theory (Figure 1).

The Interconnected Model (as shown in Figure 1) suggests that change occurs through the mediating processes of reflection and enactment in four distinct domains which encompass the teacher's world: the Personal Domain (Teacher Knowledge, Beliefs and Attitudes), the Domain of Practice (Classroom Experimentation), the Domain of Consequence (Salient Outcomes), and the External Domain (Sources of Information, Stimulus or Support). The four domains are analogous (but not identical) to the four domains identified by Guskey (1986). The mediating processes of reflection and enaction are represented in the model as arrows linking the domains. This model recognizes the complexity of professional growth through the identification of multiple growth pathways between the domains. Its non-linear nature, and the fact that it recognizes professional growth as an inevitable and continuing process of learning, distinguishes this model from others identified in the research literature. This model also identifies the mediating processes of reflection and enactment as the mechanisms by which change in one domain leads to change in another. Any processes of Professional Growth represented in the model occur within the constraints and affordances of the enveloping Change Environment (Hollingsworth, 1999).

The model locates «change» in any of the four domains. The type of change will reflect the specific domain. For example, experimentation with a new teaching strategy would reside in the Domain of Practice, new knowledge or a new belief would reside in the Personal Domain, and a changed perception of salient outcomes related to classroom practice would reside in the Domain of Consequence. Change in one domain is translated into change in another through the mediating processes of «reflection» and «enaction». The term «enaction» was chosen to distinguish the translation of a belief or a pedagogical model into action from simply «acting», on the grounds that acting occurs in the Domain of Practice, and each action represents the enactment of something a teacher knows, believes or has experienced. The empirical basis of the model has been outlined in some detail in Clarke and Hollingsworth (2002).
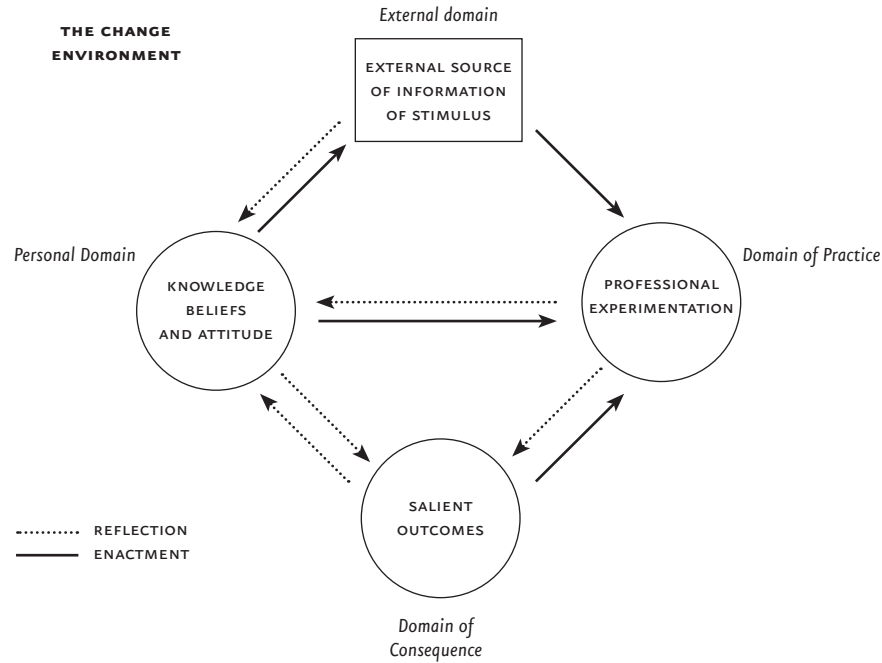
External domain

EXTERNAL SOURCE
OF INFORMATION
OF STIMULUS

Personal Domain

KNOWLEDGE
BELIEFS
AND ATTITUDE

Domain of Practice

PROFESSIONAL
EXPERIMENTATION

SALIENT
OUTCOMES

·········· REFLECTION
———— ENACTMENT

*Domain of
Consequence*

FIGURE I — THE INTERCONNECTED MODEL OF TEACHER PROFESSIONAL GROWTH
(CLARKE & HOLLINGSWORTH, 2002, P. 951)

One consistent challenge for theorists has been how to account for the demonstrable diversity of individuals' knowings within the evident commonalities of action associated with participation in a common social setting. Various theoretical positions have been constructed from which to resolve this tension. A focus on learning as a form of incrementally increasing, but differentiated, participation in an existing body of social practice has provided one useful lens (Lave & Wenger, 1991). This identification of learning with social practice is an important advance from notions of learning as simply occurring in social settings. Specifically, «learning is an integral part of generative social practice in the lived-in world» (Lave & Wenger, 1991, p. 35). The social 'situatedness' of learning can then enter the equation through consideration of the extent to which features of the social setting constrain or afford particular practices associated with learning and thereby constrain or afford the learning itself (Greeno, Collins & Resnick, 1996), delineating socially enacted tolerances within which individual idiosyncrasy can develop.

This is the description of learning that we find in closest accord with the Interconnected Model. Such a description gives, in our opinion, due recognition to situated practice and to the development of individual practice and individual theories of practice within an environment that both constrains and affords such individual variation. The two mediating processes, enaction and reflection, usefully connect to practice and to cognition and identify both activities as mediators of change.

The Interconnected Model of Teacher Professional Growth takes teacher change to be a learning process and suggests the possible mechanisms by which this learning might occur. The non-linear structure of the model provides recognition of the situated and personal nature, not just of teacher practice, but of teacher growth: an individual amalgam of practice, meanings, and context. Our support for the process of teacher growth must offer teachers every opportunity to learn in the fashion that each teacher finds most useful. If our professional development programs are to recognize the individuality of every teacher's learning and practice, then we must employ a model of teacher growth that does not constrain teacher learning by characterizing it in a prescriptive, linear fashion, but anticipates the possibility of multiple change sequences and a variety of possible teacher growth networks. Professional development programs that prioritise teacher agency are needed. Such programs require tools that inform teacher action and facilitate teacher reflection on that action. We suggest that video is such a tool.

VIDEO-BASED INTERNATIONAL CROSS-CULTURAL RESEARCH

Of all data sources currently available to researchers in education, video data seems most amenable to multiple analyses. The richness and complexity of video records of social interactions provide opportunities for reinterpretation, recoding, and for re-presentation of what is captured in the video records of social settings. Increasingly, research designs are anticipating multiple analyses of the complex data sets generated from educational settings (Clarke, Mitchell & Bowman, 2009; Clarke *et al.*, 2012). Research studies with which we have been involved have collected and configured data in anticipation of the use of such multiple analyses to realise the potential of classroom video data. We suggest that it is through multiple analyses of the same educa-

tional settings that research can come closest to matching in its findings the complexity of the situations and practices in those settings.

The *Learner's Perspective Study* (LPS) (Clarke, Keitel & Shimizu, 2006), for example, is predicated on the principle that the complexity of educational settings such as mathematics classrooms can only be studied through research approaches that match that complexity with (i) adequate recognition of the perspectives of all participants and specific embodiment in the data generation of those perspectives, (ii) deliberate utilisation of multiple analyses to provide a wide range of theoretical perspectives on the social setting and situations being studied, (iii) an acceptance from the outset of the obligation to anticipate and enact the synthesis of the multiple analyses into an integrative amalgam of interrelated complementary accounts (Clarke, 2006), and (iv) the development of «practical explanatory theory» that would provide «knowledge about the ways in which classroom activities, including teaching, affect the changes taking place in the minds of students: what students know and believe and what they can do with their knowledge» (Nuthall, 2004, p. 295).

The challenge confronting classroom researchers has always been to make confident connection between classroom activities and learning outcomes in order to optimize classroom learning environments and promote learning. We believe that serious research addressing this issue cannot be restricted to a single analytical frame, but must take a programmatic approach, where a well-equipped research team, combining a range of methodological and theoretical expertise, undertakes careful parallel analyses of high-quality, complex data. Advances in technology and particularly the growing sophistication in the research use of video bring us ever closer to the realisation of this vision.

The example of LPS illustrates one way in which video-based research can generate findings that catalyse teacher professional learning. The complete LPS research design is set out elsewhere (Clarke, 2006). For the analysis reported here, the essential details relate to the standardization of transcription and translation procedures. Three video records were generated for each lesson (teacher camera, focus student camera, and whole class camera), and it was possible to transcribe three different types of oral interactions: (i) whole class interactions, involving utterances for which the audience was all or most of the class, including the teacher; (ii) teacher-student interactions, involving utterances exchanged between the teacher and any student or student group, not intended to be audible to the whole class; and (iii) student-student interactions, involving utterances between students, not intended to be audi-

ble to the whole class or to the teacher. All three types of oral interactions were transcribed, although type (iii) interactions could only be documented for two selected focus students in each lesson. We distinguish *private* student-student interactions from whole class or teacher-student interactions, both of which we consider to be *public* from the point of view of the student.

Where necessary, all transcripts were translated into English. Transcription and translation were carried out by the local team responsible for data generation and were therefore undertaken by native speakers of the local language. The analyses reported here were undertaken on the English version of each transcript of public classroom dialogue. Analyses were conducted of 110 lessons documented in 22 classrooms located in Australia (Melbourne), China (Hong Kong and Shanghai), Germany (Berlin), Japan (Tokyo), Korea (Seoul), Singapore, and the USA (San Diego) (see Clarke, Xu & Wan, 2013a, 2013b). Figure 2 shows the number of public utterances per lesson averaged over five sequential lessons for each classroom, where an utterance is a single, continuous (uninterrupted) oral communication of any length by an individual or a group (choral). The average number of public utterances per lesson provides an indication of the public oral interactivity of a particular classroom. Lesson length varied between 40 and 45 minutes, and the number of utterances has been standardized to a lesson length of 45 minutes.

Figure 2 distinguishes utterances by the teacher (white), individual students (black) and choral responses by the class (e.g., in Seoul) or a group of
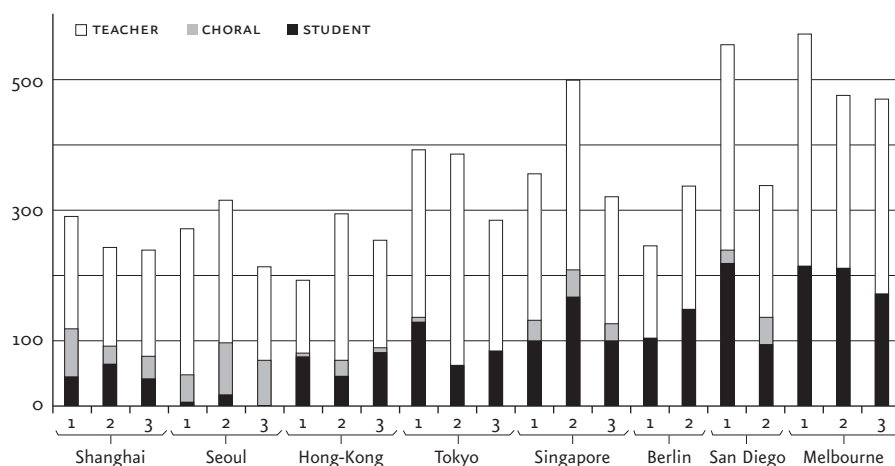

FIGURE 2 – THE NUMBER OF PUBLIC UTTERANCES PER LESSON (AVERAGED OVER FIVE LESSONS) (CLARKE, XU & WAN, 2013A, P. 21)
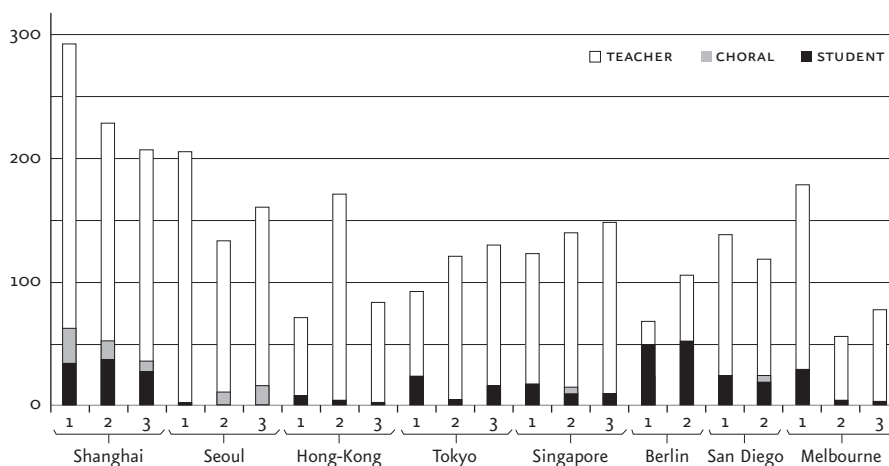
students (e.g., in San Diego) (grey). Any teacher-elicited, public utterance spoken simultaneously by a group of students (most commonly by a majority of the class) was designated a «choral response.»

It is of interest to know how many of these utterances made use of mathematical terms. Figure 3 shows the frequency of public utterances containing mathematical terms.

Shanghai 1 and the three Seoul classrooms were characterised by highly frequent choral utterances. By contrast, the classrooms in Tokyo, Berlin, and Melbourne did not appear to attach significant value to this type of utterance. The level of individual student contribution to the public classroom interactions also varied considerably.

 It must be emphasised that Figures 2 and 3 refer only to what we called public speech. The comparison of three particular classrooms (Shanghai 1, Seoul 1 and Melbourne 1) makes clear just how profound were the differences in public discourse patterns between classrooms. Figures 4a and 4b focus attention on public utterances and the public use of mathematical terms in these three classrooms.
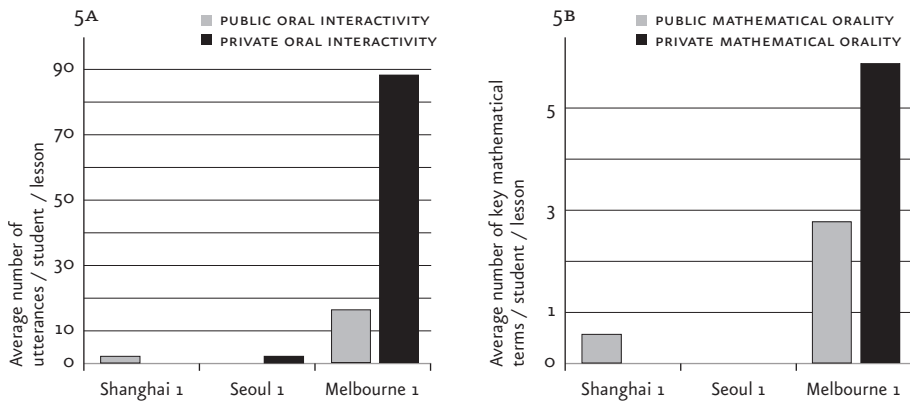
It was also possible to analyse student-student spoken interaction, where this occurred, and Figures 5a and 5b make comparison of the same three classrooms with respect to the frequency of public and private (student-student) utterances and the public and private spoken use of mathematical terms *per student per lesson*. Figures 5a and 5b show the frequencies per student averaged

4A

4B □ TEACHER ▨ CHORAL ■ STUDENT
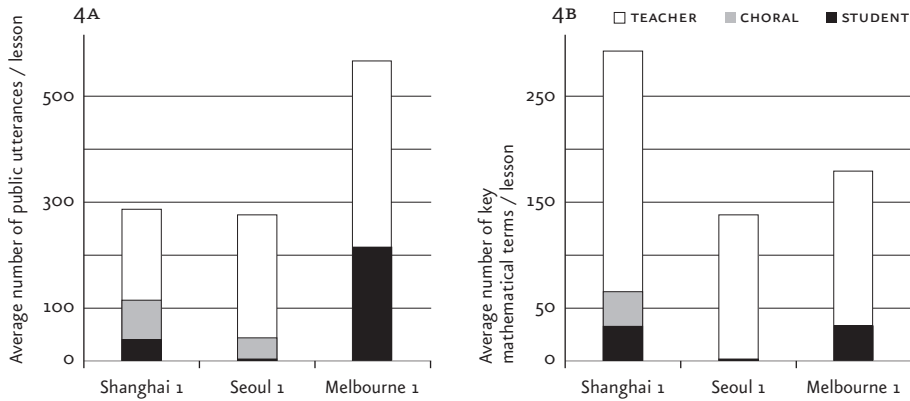
FIGURES 4A AND 4B – COMPARISON OF PUBLIC UTTERANCES (4A) AND PUBLIC USE OF
SPOKEN MATHEMATICAL TERMS (4B) IN THREE CLASSROOMS

over ten students (two different students recorded for each of the five con-
secutive lessons analysed).

It may be useful to note the number of students in each class: Shanghai
1 = 50 students; Seoul 1 = 36 students and Melbourne 1 = 25 students. The differ-
ences between the pedagogies and associated discourse patterns in the three
classrooms are evident in these two sets of figures (4a, 4b and 5a, 5b). Stu-
dent-student interaction is clearly a key mode of discursive exchange in the
Melbourne classroom, where students discussed mathematical tasks both in
mathematical and colloquial terms.

5A ▨ PUBLIC ORAL INTERACTIVITY
■ PRIVATE ORAL INTERACTIVITY

5B ▨ PUBLIC MATHEMATICAL ORALITY
■ PRIVATE MATHEMATICAL ORALITY

FIGURES 5A AND 5B – PUBLIC AND PRIVATE UTTERANCES (5A) AND PUBLIC AND
PRIVATE MATHEMATICAL TERMS (5B) PER STUDENT PER LESSON (AVERAGED
OVER TEN DIFFERENT STUDENTS – TWO PER LESSON)

In all three Shanghai classrooms and all three Seoul classrooms, there was no use of mathematical terms in private student-student interaction (Clarke, Xu & Wan, 2013b). This made it all the more remarkable that Shanghai Teacher 1 could assert in a post-lesson interview: «It is the students who have to think and talk about the problems by themselves. The role of the teacher is only to guide them. In other words, students are the active agent.» Figure 6 and Table 1 illustrate how this teacher employed whole class discussion to develop student fluency in spoken mathematics.

Studiocode, the video-coding software used, combines basic descriptive coding statistics with a capacity to reveal temporal patterns in a highly visual form (see Figure 6). *Studiocode* connects a time-coded transcript to the video record of a lesson and supports the coding of either events in the video record or the occurrence of specific terms in the transcript. Using *Studiocode*, a timeline display could be generated of the occurrence of selected mathematical terms throughout a given lesson. Figure 6 shows the occurrence of specific mathematical terms and phrases: *linear equations in two unknowns*; *equation*; *unknown*; *solution*; *integral solution*; and *solution set* in the public discussion occurring in one lesson in the classroom of Shanghai Teacher 1. We are employing 'public' in the same sense as previously: that is, spoken participation in whole class or teacher-student interaction. The occurrence of each distinct term or phrase is indicated here by a particular shade of grey. Within a shaded band, each line represents the use of a particular term, such as «equation,» by an
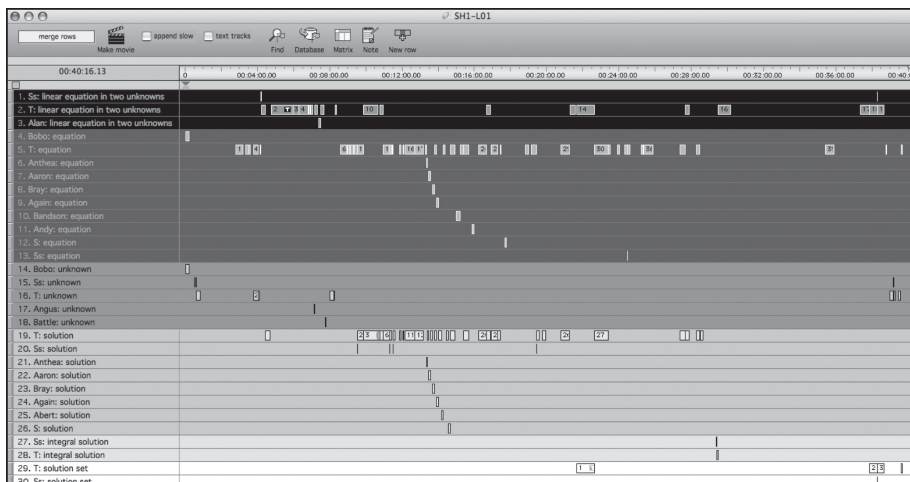

FIGURE 6. THE OCCURRENCE OF MATHEMATICAL TERMS AND PHRASES IN SHI-LOI
(CLARKE, XU & WAN, 2013A, P. 20).

individual in the classroom discussion. The width of a shaded band is an indication of the number of individuals who made use of the term in public discussion. Not surprisingly, the teacher (signified by «T») made most frequent use of each term. All other timelines refer to student use of each term.

The highly visual nature of the timeline display can reveal temporal patterns in the occurrence of the coded terms. In the case of Shanghai Teacher 1, the solicited articulation of a key mathematical term (e.g., «equation» or «solution») from a sequence of students seems to be a distinctive characteristic of that teacher's practice. Once identified, such distinctive patterns can be examined in more detail. Below is the transcript of a one-minute interaction (min: sec) focusing on the term «solution.»

TABLE I – ELICITED PUBLIC REHEARSAL OF
«SOLUTION» – CLASSROOM TRANSCRIPT (SHI-LOI)

12:42(m:s) T: So let's read ... ah, let's read question one, question one. It says... in the following pairs of number value, each of them can be matched with a pair of x and y. So, let's read this. It is asking, which of them are the **solutions** of the equation two x plus y equals three? Which are the **solutions** of the equation three x plus four y equals two? Come on, have a try.

13:10 T: So, let's take a look. How about the first one? Oh, ok, you.

13:14 Anthea: x is equal to zero, y is equal to three. It is.

13:17 T: It's an equation. That means, x is equal to zero, y is equal to three. It is... ?

13:21 Anthea: It is a **solution** of the equation two x plus y equals three..

13:24 T: A **solution.** Okay, sit down please. How about you, Aaron?

13:28 Aaron: x equals zero and y equals one over two is a **solution** of the equation three x plus four y equals two..

13:35 T: Ah, a **solution** of this. Sit down please. Let's continue. Question three, question three. Come on, (...) [Apollo and Amanda raising their hands]

13:41 Bray: If x equals negative two, y equals two, it is the **solution** of the equation three x plus two y equals two.

13:48 T: Oh,...... it's a **solution** of the equation three x plus four y equals two. A **solution**, right? Ok, sit down please. Let's continue. Come on.

13:55 Again: When x equals one over two, y equals two, it is the **solution** of the equation two x plus y equals three.

14:00 T: Okay, it is a **solution** of two x plus y equals three. Okay, sit down please. So now, x equals one, y equals one over two, come on, (...) Tell me.

14:12 Albert: When x equals one, y equals negative one over two, it is a **solution** of three x plus four y equals two.

[STUDENTS WHOSE NAMES ARE GIVEN IN FULL WERE
SUBSEQUENTLY INTERVIEWED; T = TEACHER, THROUGHOUT]

This level of frequency of student spoken articulation of key mathematical terms was evident in all five lessons analysed from this Shanghai classroom. The pattern of elicited rehearsal of a key term, so visible in Figure 6 and Table 1, was also clearly evident in the practice of Shanghai Teacher 2 and Shanghai Teacher 3.

It has been our experience that consideration by practising teachers of the distribution of opportunities for 'spoken mathematics' in the various classrooms has served as a powerful catalyst for teacher discussion in pre-service and in-service settings. Prompts such as «Which classroom most resembles your own?» have generated lively and fruitful discussion. In terms of the Interconnected Model displayed in Figure 1, the preceding findings from the Learner's Perspective Study constitute an «External Source of Information or Stimulus» and may prompt teacher reflection leading to the reconstruction of knowledge and beliefs in the Personal Domain or action leading to some form of classroom experimentation in the Domain of Practice.

VIDEO CASES AND TEACHER PROFESSIONAL LEARNING

It is important to clarify what is meant by a case, as this term is used in professional development situations. Cases, for the purposes of teacher professional development, are candid, dramatic, accessible representations of teaching events or series of events. Barnett (1999) has recently provided an extremely practical introduction to narrative-based cases.

Other professions (such as law, medicine, social work) make extensive use of the study of cases for professional development. Most people would have some idea of the function served by «cases» in such professions. Teaching has now adopted the strategy of case-based professional development (Barnett, 1991, 1999; Louden & Wallace, 1996; Merseth, 1991; Wasserman, 1993). Whether we are dealing with the professional development of practicing teachers or pre-service teachers, cases offer identifiable benefits. In particular, a case-based approach should be contrasted with a principles-based approach. Every profession has principles of good practice, and it is tempting to see professional development as consisting of experienced practitioners passing on these principles to novices or less experienced colleagues through either formal lectures or through some variation on the apprenticeship/internship model.

We would, however, question the value of any professional development program based solely on the communication of such principles.

In the case of novices, «principles alone» tend to confirm the beginner's already oversimplified notion of what teaching is all about. In the case of more experienced practitioners, an in-service program restricted to the communication of principles implicitly disregards the expertise of the practising teacher, offering little opportunity for the teacher or the group to benefit from the accumulation of practical wisdom present in any gathering of professionals. For both groups, beginners and veterans, principles alone minimize the opportunity for participants to relate the content of the professional development program to their existing practice or to classroom or school settings with which they are familiar. By contrast, cases connect teachers to professional practice. In the remainder of this section, we focus on the use of Video Cases for professional development.

It is a key feature of cases that they offer a common point of reference for practitioner collegial reflection. Asking practitioners to reflect on specific instances of professional practice, captured anecdotally in text form or visually through the use of videos, ensures that the resultant discussion will be firmly grounded in a shared familiarity with a particular incident in a particular educational setting. It has become common in professional development programs to have participating teachers share good practice and to reflect on their classroom experimentation. This approach affirms the expertise of the participants and can create a collegial environment for the sharing of good practice. A disadvantage, however, is that discussion centres on individual participants' accounts of their experiences and practice. The discussion of these accounts is coloured by one teacher's ownership of the recounted incident and constrained by the group's sensitivity to the personal nature of the accounts. One virtue of a case discussion is that the situation being discussed is held in common by the group. While each teacher will interpret the case in their own terms and focus on different aspects of the case, the case itself serves as a common reference point and a shared «experience.» One teacher's interpretation of the case can be evaluated by other group members in terms of its fidelity to a situation familiar to all. Since the case is held jointly rather than by one individual, discussion is unrestrained by any identification with one particular group member.

Case discussions are intended to develop practical knowledge that allows a teacher to judge a situation or context and take prompt action on the basis of

knowledge gained from similar situations in the past. In this, the case methods approach bears strong similarity to some programs seeking to develop problem solving skills through expanding participants' repertoire of problem situations and associated actions, rather than through the accumulation of decontextualized general problem solving strategies. On this basis, case methods can appeal to the logic of situated cognition for theoretical support (Lave, 1988; Lave & Wenger, 1991).

Given the lack of prescription offered by the case methods approach, it is interesting to examine the research on the consequent practice of teachers with extended experience of case discussions. Teachers involved in case discussions appear to move toward a more student-centred approach. These teachers appear to learn to adapt and choose materials and methods that reveal student thinking, and anticipate and assume rationality in students' misunderstandings (Barnett & Friedman, 1996).

Recently several professional development programs have included video recordings of classroom incidents as a catalyst to discussion, rather than the narrative vignettes that characterize the text-based case methods approach. The use of such Video Cases has taken many forms.

1. *Cross-cultural Video Cases*

When teachers view videotapes of classrooms the familiarity of the classroom setting can reduce the power of the video clip to catalyse teacher reflection. However, if the videotaped lessons are taken from a very different culture, the teacher's assumptions about accepted and expected practice no longer apply. In this situation, teachers are more inclined to interrogate the videotape and, by implication, their own practice. The unfamiliarity of what they are viewing challenges their assumptions about what is acceptable, competent teaching practice. In our experience, experienced teachers, in particular, find video clips of lessons in other countries interesting. Teachers interact with such video clips by either challenging the legitimacy of the less familiar practices of another country or by justifying their own practice, where this is different from the teacher actions captured in the video clip. Videotapes of classrooms from different countries, such as those in the *TIMSS Video Study* public access collection (www.timssvideo.com) offer opportunities for such teacher interaction.

2. *Examples of Practice*

In a Californian program directed by Nanette Seago, American teachers are guided through a discussion of video recordings of American classrooms (typically the greater part of a lesson). Familiarity with the socio-cultural context of the lessons enables the discussion groups to undertake fine-grained interpretation of the teacher's and students' actions. In the discussions, teacher interaction with the video material is mediated by the teachers' construal of the video recorded practice as either exemplary or problematic. The immediacy of the video record can encourage the objectification of the teacher and the discussion can take on an evaluative tone that is less concerned with exploring and understanding classroom practice and more concerned with identifying shortcomings in the teacher's approach. However, as has been shown by Nanette Seago, in the hands of a good Case Discussion Facilitator, teachers can focus on «what could have been done?» rather than «what should have been done?» and the video clip can stimulate group participants to share their own teaching practices and beliefs and relate these to those evident in the video clip and those of the other group members.

3. *Structured Illustration*

Collated video examples of different teaching approaches are in widespread use in pre-service and in-service teacher education programs. For example, a two-DVD set of video material, entitled *Effective Mathematics Teaching: Algebra and Fractions*, was commissioned by the Victorian Department of Education and Early Childhood Development.. Short video clips were organised into categories of activity types and distributed to schools to illustrate different approaches to the teaching of algebra and fractions. In another initiative, video resources were developed to support the education of pre-service teachers at the University of Melbourne. The material was presented as an interactive DVD and prospective teachers were guided through structured interactions with video clips of elementary and high school classrooms and videotaped interviews with teachers and students. The video clips were clustered into nine «Focus Areas» such as «Student Learning and Teaching Purposes», «Individual and Group Differences» and «Evaluating Teaching.» The interaction of prospective teachers with this material was guided by questions and tasks integrated into the program and supported by linked interviews with teachers and students, frequently discussing the video clip just viewed. Electronic notebook facilities were provided within the program environment and an Audit Trail was built

into the program so that a student's interactive pathway through the material could be reviewed by students and lecturers.

4. *Structured Investigation*

MILE (Multimedia Interactive Learning Environment) is a highly structured, interactive learning program implemented at the Freudenthal Institute in the Netherlands, whereby pre-service (or in-service) teachers are assisted to utilize classroom video to undertake guided investigations related to issues of pedagogy and learning. Within MILE, prospective teachers can view and review fragments of lessons. The selection of lesson fragments for inclusion in the MILE data bank was based on criteria related to subject matter and pedagogical and educational points of view that were felt to be on display in the chosen video clips. The full MILE database consists of more than three thousand five hundred video clips or lesson fragments. Each fragment is a solitary case, but at the same time is related to the lesson as a whole. Prospective teachers can carry out full text retrieval searches of the class dialogue (transcribed) and of synopses of the lessons and lesson fragments. In addition, some preparatory coding has already been carried out on the lesson fragments and prospective teachers can search the lesson fragments using these codes. The intention is that the video material provides a vehicle for prospective teacher investigation of professional activity and thereby stimulates their reflection on the nature and optimisation of that activity.

5. *Problematic cases*

Scripted videos could be used to illustrate either exemplary practice or problematic situations. In the example with which we are most familiar problematic classroom situations were simulated using the students and facilities at a local high school. Each situation was scripted, each was intended to be problematic in some way, and the scripted scenario and several alternative teacher strategies for each situation were acted out and recorded on videotape. The resultant video clips were clustered into thematic groups such as classroom management, content-related problems, pedagogical problems, and so on. The set of video clips was used in a teacher training program at Monash University in Australia to promote discussion (Clarke, 1986). Scripted videos of problematic cases have the virtue of not contravening good ethical practice since the competence of neither teacher nor students is in question. In contrast, the use in professional development programs of actual video clips of

problematic classroom situations runs the risk of showing either the teacher or the student(s) in a bad light, with possible negative consequences for reputation and career.

Video cases allow participants to construct their own interpretations of the classroom depicted and to attend to those aspects they consider important. While this holds the potential for greater participant interest, it also holds the threat of a discordant, unfocussed discussion in which a variety of personal agendas compete for discussion time. The role of a case discussion facilitator in framing the group's discussion assumes new significance as the variety of possible themes for discussion expands. Conversations that we have had with those using classroom video clips suggest an inclination on the part of teachers to be immediately critical of the teacher depicted in a video. Again, the role of the case discussion facilitator is critical. The distinction between «should» and «could» is particularly useful, and we paraphrase this approach as: «Focus on what the teacher *could* have done, not what they *should* have done.» It seems to us that this distinction is at the heart of a productive case discussion.

VIDEO AS A TOOL TO SUPPORT TEACHERS' REFLECTION ON THEIR OWN PRACTICE

In conventional models of professional development, the university academic is positioned as 'outside expert' with the role of sharing knowledge and expertise with the community of teachers who are consequently positioned as 'needy', lacking the academic's knowledge or expertise. In the last decade, research on professional development focused on bringing together science and classroom practice, for example with a focus on professional communities (Lachance & Confrey, 2003) or communities of practice (Krainer, 2003; Zaslavsky & Leikin, 2004). These efforts of fusing teacher education and research are mostly intervention research; that is, the same people responsible for the intervention do the research. In neither situation, in-service professional development or research, can the relationship between academic and teacher be described as a partnership.

Recently developed programs in several countries have contested this positioning and constructed programs in which significant agency resides with the participating teachers. In the instance reported here, a partnership was

established between university academics and teachers for the purpose of utilising video vignettes of the teachers' classroom teaching to catalyse the group's collective learning about classroom practice (Gorur, 2007). The Case-Based Learning (CBL) group discussions provided a forum for a process of collaborative reflection on the stimulus video material (see below for an outline of the procedure).

In this section of the paper, we explore the possibilities for teacher professional growth through academic-teacher collaboration using video case data generated in the classes of the participating teachers. Video case studies capture the 'visual, nonverbal, physical, tactile, and verbal elements of teaching', and 'bring together both teaching action and space for reflection' (Harris, Pinnegar & Teemant, 2005). Further, such records of everyday teaching practice, when used skilfully by collaborative teams of teachers and academics, afford the possibility of building theory and couching such theory in the language of teacher learning and everyday classroom practice (Shulman, 1992; Shulman & Shulman, 2004).

Cases often serve to focus attention on particular issues or dilemmas that may be encountered in 'real' classrooms (Harris *et al.*, 2005). When cases are specifically written for professional learning, the focus of learning and the 'content' to be learned become pre-determined, at least in intent, with pre-defined outcomes. This approach we term 'embedded' – the content is embedded in the cases. Previously, the case method approach to teacher professional development has typically consisted of narrative instantiations of classroom situations (Barnett & Friedman, 1996). In our approach, practicing teachers use video tapings of their own classroom practice and select and share excerpts that they think would provide stimulus for useful discussion (Clarke & Hollingsworth, 2000). This results in open-ended exploration of issues, what we call the 'encounter' approach. The cases become 'boundary objects' that provide multiple points of entry and broker connections between theory and practice (Yoon *et al.*, 2006).

THE CASE-BASED LEARNING (CBL) PROCESS

The CBL program involved a dozen teachers from different schools in Melbourne, Australia; two university academics; and two observers with backgrounds in teaching and research. Each teacher was invited to have a lesson of choice videotaped, and a DVD of the video footage was provided to the

FIGURE 7 — STANDARD SPLIT-SCREEN VIDEO RECORD USED AS CBL STIMULUS

teacher. The methods of videotaping varied according to the budget available, and ranged from sophisticated, professional jobs with two or even three camera formats, with high quality microphones that picked up student group work discussion as well as teacher voice and whole group discussions and split-screen presentation, to more modest one-camera recordings. Figure 7 shows the most common split-screen display, in which two images (one from the «teacher camera» and one from the «whole class camera») were combined in a single, synchronised record of the classroom.

The teacher involved was then required to select a five minute segment of their choice, which represented either a puzzle that needed explication, an interesting or unexpected learning or teaching event or outcome, an instance of trying out a particular method, such as a thinking routine, or simply one that would provoke discussion and lead to new insights. The presenting teacher introduced the segment with some background information about the lesson/unit in general, and then focused the audience by providing the reason the particular segment had been chosen for discussion.

The discussion that followed was facilitated by one of the university academics. The structure of discussion was deliberately loose, rather than structured, so that new directions could emerge and new discussion points be raised. The focus of discussion was not whether the lesson had been taught well, or whether the teacher had 'done the right thing'. Rather, the focus was on issues in student learning, teacher learning and teaching practice, and on the possible consequences for student learning with alternate teacher choices.

The meetings were each about two hours in duration and were held monthly. Participation protocols were developed to ensure the discussion remained fruitful and the focus did not deviate toward what the teacher

'ought' to have done. Notes from the session were posted on the group's electronic discussion forum, which helped to continue discussion between meetings. Members of the group shared papers or articles or opinions that spoke to some of the discussion via this forum. Observer's notes are reproduced below to provide insight into the nature of the group discussion.

> Example: Gary (précis from notes taken by observer)
> Gary has chosen to share a segment that shows a group of his students in a passionate discussion for several minutes without progressing far in their thinking. Gary wonders if he should view this part of his lesson as a success or a waste of time. Was there merit in allowing the group to continue the discussion when they were off the track? Should he have insisted on equity in participation? Should he have intervened with a question that might have nudged their thinking out of their current quagmire, or given them more time to work it out for themselves? What, he asks, do members of the case-based learning group think he could have done? The group discuss various approaches that Gary could have taken at this point in the lesson, carefully considering the potential outcomes of each one. They recognise that some of the approaches suggested have more merit than others, and decide to discard those that they agree are less helpful. It's astonishing that a five-minute piece of recording yields such rich material to ponder. The two hours set aside for discussion seem to evaporate all too soon. Questions and ideas remain active in the participants' minds even after the meeting closes, and the discussion spills over into the group's wiki where the dialogue continues.

The Participants' Perspective
The participants in this event were invited on the basis of their past interest in professional learning, and were an enthusiastic and dedicated group. While the style of discussion did not uniformly suit everyone (one participant stated that she was unable to think and speak on the spot, and felt she was not contributing adequately to the discussion), all participants felt that the discussions spoke directly to their classroom experience, and that they found themselves reflecting on the issues raised in the discussion long after the meeting sessions. In the words of one participant:

> The themes of conversations really stick in my mind, I think because during the CBL session I had to make active links with my classroom. [For example]

after we spoke about the challenges of grouping students, for weeks I deliberated on the way I grouped my students.

The teachers found this form of professional learning to be radically different from other forms of professional development opportunities they had encountered. Many commented on the validation of the importance of the ordinary and everyday aspects of teaching that this forum provided. The focus on the nitty-gritty and the mundane – the daily business of classroom life spoke directly teachers' everyday practice.

> CBL has ordinary teachers as the focus. Normal teachers doing what they do every day. It is not whiz bang «Here's a set of tasks for next week's maths lessons», it is far deeper and [more] meaningful. Real issues about real classrooms from real teachers.

The heterogeneity of the group meant that important insights were gained about (and from) the different assumptions about learners and learning made in different classrooms – prompting reflection on their own assumptions as reflected in their classrooms.

> [It was] intriguing to see classes in different levels to the one I teach in operation. In that regard, [it was] very interesting also to see the way that students at the different levels express their thinking and do their thinking.

The nature of video data was also an important material actor, since it could bring the classroom to the discussion, be viewed over and over, and 'saw' things literally from different perspectives. Participants reported that once they had overcome the initial resistance to being filmed, they found the footage to be very valuable. They noticed things about themselves, their students and the environment of which they were previously unaware. As one participant noted,

> One of the most significant outcomes is the variety of classroom issues for consideration which have arisen: from the arrangement of furniture in different levels of classrooms to deep considerations of student thinking. All of these discussions have served to open up my thinking about my classroom and the many aspects of it, which I should be thinking about or at least be aware of.

Teachers also reported becoming more aware of their own decision-making processes and the impact their decisions had for students and student learning.

> To view the body language and the way we carry ourselves as educators- what we say and do and how that may influence our students... It [p]oses more questions: hidden curriculum, values, ethics, standards, etc.

Some continued to have their lessons taped for their own reflection and growth, beyond the requirement of the CBL participation. One teacher reported that the experience of having a camera in the classroom as a 'seeing eye' has prompted her to develop a 'seeing eye' within herself, so that she is much more conscious of the goings-on in the classroom as the camera might see it.

With the teacher setting the focus for discussion at the time of presentation, issues raised were the stuff of practitioners' interests and dilemmas. Daily issues became matters worthy of discussion. Here the encounter nature of learning, where the agenda for discussion was not pre-determined by the academics but by the presenting teacher, and where discussion sometimes took unexpected turns, also served to provide opportunities for teachers to see themselves as experts and to validate their own questions, knowledge and experience. It was a recurrent experience of CBL discussions that an excerpt chosen by a teacher would trigger associations among the group and catalyse discussion that ranged far beyond the features or issues that had initially prompted the teacher to select that excerpt. In the language of the model in Figure 1, the salient features of the excerpt were a matter for individual interpretation and group discussion and led to a stimulating negotiation of the participants' meanings and values.

CONCLUDING REMARKS

This paper was intended to illustrate some of the ways in which video can be used to facilitate teacher reflection and enaction. In all of the examples provided in this paper, the video material has provided an explicit or an implicit bridge between the contexts portrayed in the stimulus material and the classrooms of the teachers participating in the in-service or pre-service programs. In the case of the use of cross-cultural research, the video material provides a warrant for the legitimacy of the shared findings; a warrant that encourages

teacher engagement with the shared data as fundamentally grounded in the practice of actual classrooms. This immediacy and connection with practice is even more apparent in the discussion of video cases and teachers' reflection on their own practice. Our concluding remarks will focus on the conditions under which video might best support case-based approaches to teacher professional learning.

If video cases are to stimulate productive teacher reflection, then the discussion of such cases must be carefully framed, centring on possibility rather than prescription. Our increasing use of video material to facilitate teacher reflection on classroom practice may (i) render visible, for the first time, some of the unnoticed practices of teachers[1]; and (ii) facilitate the development among the teaching community of a new vocabulary by which we might describe teaching practice. Both these developments are important. Many of the practices of our most capable teachers have a subtlety that renders them effectively invisible to casual observation. Frequently this will be because the teacher's actions carry a significance or meaning that is shared by teacher and class but not readily apparent to an outside observer. Videotape, which lends itself to re/view, can facilitate the sort of fine-grained «data-driven» discussion likely to reveal the nature and significance of such practices. Some of these practices are not even represented in our discourse. These might include the strategies by which a teacher signifies a willingness to accept student contributions to class discussion or through which student-student interaction is sanctioned or promoted. It may consist of oral inflections signifying invitation or non-verbal acts, gestures, body posture or physical location in the classroom that serve to signify to students that «the floor is yours.» Such strategies may not yet have labels within the profession and may only become part of the discourse of the teaching profession through the provision of the opportunity for teachers to discuss video records of classroom practice.

The other product that may emerge from teacher discussions of video material is the body of «principles or theories of practice» lying behind teacher classroom decision-making. The existence of such theories of practice has already been postulated in Shulman's conception of the wisdom of practice (Shulman, 1987). Using video material as a catalyst for discussion, we can facilitate the articulation of teachers' theories of practice and construct their professional development experiences on that basis. Video material can provide open-ended, minimally cued stimulus more likely to facilitate the articulation of the teachers' actual theories of practice.

One of the important objectives of the CBL project was to promote and refine teacher professional dialogue (including the development of protocols for discussion). This appears to have been achieved most successfully, as one of the observers noted:

> The role of the discussion facilitator is vital in protecting the presenting teacher from thoughtless, tactless, repetitive and overlong comments from other group members. The discussion rules have to be clearly set out. I noticed that respectful collegiality grew as people worked together over time and the facilitator [took] a less dominant role. Teachers need time to learn how to 'look and talk' in the CBL context.

In the words of one participant, his experience in CBL brought home to him what professional learning teams could achieve:

> [T]he strength and effectiveness of a group of teachers meeting regularly, coming to at least know each other on a professional level and the depth and frankness of discussion which consequently follows...

Several members of the CBL group are now setting up and facilitating similar CBL forums within their schools. We consider this development to be the most compelling endorsement of the value of video as a significant facilitator of teacher reflection and enaction.

REFERENCES

BARNETT, C. (1991). Building a case-based curriculum to enhance the pedagogical content knowledge of mathematics teachers. *Journal of Teacher Education, 42*, 263-272.

BARNETT, C. (1999). Cases. *Journal of Staff Development*, Summer Issue, 26-27.

BARNETT, C., & FRIEDMAN, S. (1996). Mathematics case discussions: Nothing is sacred. In E. Fennema & B. Scott-Nelson (Eds.), *Mathematics teachers in transition* (pp 381-399). Hillsdale, NJ: Lawrence Erlbaum.

CLARKE, D. J. (2006). The LPS Research Design. In D. J. Clarke, C. Keitel & Y. Shimizu (Eds.), *Mathematics Classrooms in Twelve Countries: The Insider's Perspective* (Chapter 2, pp. 15-37). Rotterdam: Sense Publishers.

Clarke, D. J. (2013). Contingent conceptions of accomplished practice: The cultural specificity of discourse in and about the mathematics classroom. *ZDM: The International Journal in Mathematics Education 45*(1), 21-33.

Clarke, D. J., & Hollingsworth, H. (1994). Reconceptualising teacher change. In G. Bell, B. Wright, N. Leeson & J. Geake (Eds.), *Challenges in mathematics education: Constraints on construction. Proceedings of the Seventeenth Annual Conference of the Mathematics Education Research Group of Australasia* (Vol. 1, pp. 153-164). Lismore, NSW: Southern Cross University.

Clarke, D. J., & Hollingsworth, H. (2000). Seeing is understanding: Examining the merits of video and narrative cases. *Journal of Staff Development, 21*(4), 40-43.

Clarke, D. J., & Hollingsworth, H. (2002) Elaborating a model of teacher professional growth. *Teaching and Teacher Education, 18*(8), 947-967.

Clarke, D. J., Keitel, C., & Shimizu, Y. (Eds.) (2006). *Mathematics classrooms in twelve countries: The insider's perspective.* Rotterdam: Sense Publishers.

Clarke, D. J., Mitchell, C., & Bowman, P. (2009). Optimising the use of available technology to support international collaborative research in mathematics classrooms. In T. Janik & T. Seidel (Eds.), *The power of video studies in investigating teaching and learning in the classroom* (pp. 39-60). New York, NY: Waxmann.

Clarke, D. J., Xu, L. H., Arnold, J., Seah, L. H., Hart, C., Tytler, R., & Prain, V. (2012). Multi-theoretic approaches to understanding the science classroom. In C. Bruguière, A. Tiberghien & P. Clément (Eds.), *Proceedings of the 2011 Biennial Conference of the European Science Education Research Association* (Part 3, pp. 26-40). Lyon, France, September 7 to 11, 2011 (e-Book published March 23, 2012).

Clarke, D. J., Xu, L., & Wan, V. E. V. (2013a). Spoken mathematics as an instructional strategy: The public discourse of mathematics classrooms in different countries. In B. Kaur, G. Anthony & D. Clarke (Eds.), *Student Voice in Mathematics Classrooms around the World* (pp. 13-32). Rotterdam: Sense.

Clarke, D. J., Xu, L., & Wan, M. E. V. (2013b). Students speaking mathematics: Practices and consequences for mathematics classrooms in different countries. In B. Kaur, G. Anthony, M. Ohtani & D. J. Clarke (Eds.), *Student Voice in Mathematics Classrooms around the World* (pp. 33-52). Rotterdam: Sense.

Clarke, D. M. (1986). *Critical incidents in the mathematics classroom: Teacher notes to accompany video.* Clayton, Victoria: Mathematics Education Centre, Monash University.

Darling-Hammond, L., & Snyder, J. (2000). Authentic assessment of teaching in context. *Teaching and Teacher Education, 16,* 523-545.

Fullan, M., & Stiegelbauer, S. (1991). *The new meaning of educational change.* (2nd Edition). New York, NY: Teachers College Press.

Gorur, R. (2007). Making a Case for Learning. *Professional Educator, 6(4),* 10-12.

Greeno, J. G., Collins, A. M., & Resnick, L. (1996). Cognition and learning. In D. C. Berliner & R. C. Calfree (Eds.), *Handbook of educational psychology* (pp. 15-46). New York, NY: Simon & Schuster Macmillan.

Guskey, T. R. (1986). Staff development and the process of teacher change. *Educational Researcher, 15(5),* 5-12.

Hall, G. E., & Loucks, S. (1977). A developmental model for determining whether the treatment is actually implemented. *American Educational Research Journal, 14,* 263-276.

Harris, C. H., Pinnegar, S., & Teemant, A. (2005). The case for hypermedia video ethnographies: Designing a new class of case studies that challenge teaching practice. *Journal of Technology and Teacher Education, 13(1),* 141-161.

Hollingsworth, H. (1999). *Teacher professional growth: A study of primary teachers involved in mathematics professional development.* PhD Thesis, Deakin University, Burwood, Victoria, Australia.

Johnson, N. (1996). Reconceptualising schools as learning communities. *Reflect, 2(1),* 6-13.

Krainer, K. (2003). Teams, communities & networks. *Journal of Mathematics Teachers Education, 6,* 93-105.

Lachance, A., & Confrey, J. (2003). Interconnecting content and community: A qualitative study of secondary mathematics teachers. *Journal of Mathematics Teacher Education, 6,* 107-137.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life.* Cambridge: Cambridge University Press.

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

Louden, W., & Wallace, J. (1996). *Quality in the classroom: Learning about teaching through case studies.* Rydalmere, NSW: Hodder Education.

Merseth, K. (1991). *The case for cases in teacher education.* Washington, DC: American Association of Higher Education and the American Association of Colleges for Teacher Education.

Nuthall, G. (2004). Relating classroom teaching to student learning: A critical analysis of why research has failed to bridge the theory-practice gap. *Harvard Educational Review, 74*(3), 273-306.

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

Shulman, L. S. (1992). Toward a pedagogy of cases. In J. H. Shulman (Ed.), *Case methods in teacher education* (pp. 1-32). New York, NY: Macmillan.

Shulman, L. S., & Shulman, J. H. (2004). How and what teachers learn: A shifting perspective. *Journal of Curriculum Studies, 36*(2), 257-271.

Wasserman, S. (1993). *Growing teachers: Learning about teaching from studying cases.* New York, NY: Teachers College Press.

Yoon, S., Pedretti, E., Bencze, L., Hewitt, J., Perris, K., & Van Oostveen, R. (2006). Exploring the use of cases and case methods in influencing elementary preservice teachers' self-efficacy beliefs. *Journal of Science Teacher Education, 17,* 15-35.

Zaslavsky, O., & Leikin, R. (2004). Professional development of mathematics teacher educators: Growth through practice. *Journal of Mathematics Teacher Education, 7*(1), 5-32.