Making connections: Lessons on the use of video in pre-service teacher education

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This paper reports on the trial of video excerpts of mathematics teaching used in teaching pre-service primary teachers in a four-year undergraduate teacher education degree program. After viewing a video excerpt of teaching a basic mathematics concept, pre-service teachers were asked to identify the focus of the lesson and aspects of the teacher's practice that were effective; list questions they would ask the teacher; identity anything that they would do differently and what they would do next; compare the teaching videoed with that observed during professional experience in schools; describe the extent and ways in which it contradicted or confirmed their existing beliefs about effective mathematics teaching; and to assess the value of video excerpts as a teaching tool. The findings suggested that pre-service teachers struggled to see beyond readily evident aspects of teaching, such as the use of concrete materials. Most reported that the videos showed teaching that was similar to teaching they had observed and that confirmed their existing beliefs. However, the pre-service teachers were positive about the use of video excerpts in their course. The paper concludes with recommendations for realising the potential of video to assist pre-service teachers to observe and reflect on teaching.

Keywords teacher education • mathematics teaching • videos of teaching • pre-service teachers • teacher beliefs

The Use of Video Excerpts in Teacher Education

The use of video excerpts in pre-service teacher education has become common (Star & Strickland, 2008), and is valued because it provides the opportunity for classes to view the same teaching and learning episode and to share in a discussion of what has taken place. In contrast to the professional experience in school classrooms that is a usual part of pre-service teacher education courses, the use of video excerpts allows observations to be made in a social context that allows for discussion. It can also increase the range of teachers, students, settings, pedagogies and content to which pre-service teachers are exposed (Star & Strickland, 2008), as well as providing an opportunity for pre-service teachers to take a critical look at the interactions between the mathematics teacher, the students and the mathematics being learned (Stein, Smith, Henningson, & Silver, 2000).

Discussion that follows viewing of videos of teaching can assist pre-service teachers to appreciate alternative viewpoints and to think more critically (Lin, 2005). Blomberg, Stürmer and Seidel (2011) described how video excerpts could be used to assist pre-service teachers to observe and make sense of classroom activity; a capacity they referred to as professional vision. Videos of teaching are, therefore, regarded as an effective means of

deepening pre-service teachers' learning (Llinares & Valls, 2010). In addition, they can assist pre-service teachers in making their beliefs about mathematics explicit (Chval, Lannin, Arbaugh, & Bowzer, 2009).

A further motivation for the use of video excerpts is the perceived dichotomy between the mathematics pedagogy that pre-service teachers are encouraged to adopt through their university studies and the practices that they encounter in classrooms through their practical experiences (Lin, 2005; Taylor, 2002). There is evidence that few pre-service teachers are able to see the connections between units undertaken at university and their future career until very late in their studies (Clark & Walsh, 2002). There is also evidence that pre-service programs are most effective in influencing pre-service teachers' beliefs and attitudes in relation to classroom practices that can be modelled in university classroom settings (Beswick, 2006), but large pre-service teacher cohorts and other constraints mean that university teaching settings are often necessarily quite different from school classrooms. In addition, we know that pre-service teachers regard classroom experience as the best teacher (Richardson, 1996), and that the most highly valued aspects of their university studies are those perceived as having greatest classroom relevance (Beswick, 2006). Practice-based strategies, such as videos, have been found to be effective in bridging the perceived gap between theory and practice (Lin, 2005; Taylor, 2002) through challenging pre-service teachers' images of mathematics and mathematics teaching (Taylor, 2002), and in developing their skills in observing teaching (Santagata, Zannoni, & Stigler, 2007). Appropriate video excerpts for such purposes depict teachers, classroom situations, and curricula with which the pre-service teachers can identify (Brophy, 2004, cited in Sherin, Linsenmeier, & van Es, 2009) and enable pre-service teachers to articulate strong opinions (Chval et al., 2009). Chval et al. found that this was achieved most effectively by using videos that countered pre-service teachers' experiences. It would be reasonable to suppose that videos in settings familiar to pre-service teachers and involving teachers with whom they can identify but which, nevertheless, depict teaching and learning that is counter to their expectations (based on their experience) might be most effective.

An important potential benefit of the use of video excerpts that is less explicit in the literature is the contribution they might make to the holistic development of teacher knowledge defined broadly according to Shulman's (1987) seven types of knowledge. In particular his notion of pedagogical content knowledge (PCK) and its more recent elaborations by Ball and colleagues (e.g., Ball, Thames, & Phelps, 2008), presents a challenge for teacher educators because it arises from a complex interaction of content knowledge and knowledge of general pedagogy that does not lend itself easily to explication in traditional lecture and tutorial situations. PCK is not simply the result of an additive combination of content and pedagogical knowledge and hence cannot be developed by separate attention to these knowledge types. Rather, it involves particular mathematical knowledge that is different from that required by numerate individuals who are not teaching and from the mathematical knowledge of mathematicians (Ball, et al., 2008). It includes knowledge of ways in which mathematical concepts can be represented, how they interconnect, the underpinning understandings upon which they depend, and their place in the overall development of mathematical competence. Video excerpts seem suited to developing an appreciation of the nature and scope of PCK because they can enable pre-service teachers' attention to be directed towards specific aspects of the teachers' role and the knowledge entailed whilst at the same time seeing these aspects embedded in real teaching situations in which the teacher must attend to multiple demands and constantly make instructional

decisions within the flow of events. They thus appear to offer an effective way to raise pre-service teachers' awareness of the complexity of teaching and to begin to equip them with the cognitive skills needed to operate in classroom environments.

Learning to Notice

What observers *see* when they observe teaching, either in real classrooms or recorded on video, is dependent upon what they bring to the experience. This includes their own experiences of learning and teaching; their knowledge of the subject (in this case, mathematics), of pedagogy, and of students; and their own beliefs — all influenced by their experience of the subject and how it is taught and learned. As James (1890, cited in Mason, 2005) pointed out, we attend to that which we are tuned to notice. This statement includes the implication that something must be noticed before it is attended to. Mason (1998) described the structure of attention in terms of the different loci (e.g., on immediate classroom events or on an upcoming staff meeting that will happen somewhere else), foci (multiple as when a teacher simultaneously works with an individual students and monitors the class, or single) and forms (diffused as when one contemplates a scene and allows thoughts to drift or focussed on specific details of an object at hand) that it can take.

The constructs of noticing and attending are not clearly distinguished in the literature. For example, Blomberg et al. (2011, p. 1132) described noticing as "identifying significant components of teaching and learning with the potential to influence student learning – for example, understanding student thinking …". This seems to incorporate aspects of Mason's (1998) attending and also the application of knowledge, even though Blomberg et al. regarded knowledge-based reasoning as separate from noticing. In this paper we use noticing and attending in ways that align more closely with Mason's usage: pre-service teachers notice certain things and then attend to them in different ways. Further, they attend to them in different ways from an experienced teacher or from a mathematics educator.

This helps to explain the finding of Philipp et al. (2007) that pre-service teachers who watched and analysed videos of children solving mathematics problems showed greater change in their beliefs about mathematics teaching and learning than those who observed teaching in real classrooms even when the teachers they actually observed were chosen to be likely to model teaching that was consistent with the aims of their course. Philipp et al. (2007) concluded that it was the opportunity afforded by videos to prompt pre-service teachers to reflect more deeply on what they observed that was critical. That is, their attention could be directed towards the students' mathematical activity (Philip et al., 2007). In Mason's (1998) terms, videos can enable pre-service teachers to be prompted to shift their attention from viewing the mathematics from their own point of view to also seeing it as evidence of the students' mathematical thinking and as information that could inform teaching. In contrast to this, in actual classrooms, including during professional experience, there is a tendency for pre-service teachers to notice that which confirms their existing beliefs. Morris (2006) suggested that pre-service teachers' attention could be directed differently according to the conditions under which a video excerpt is watched. In particular, when pre-service teachers were free to decide upon the effectiveness or otherwise of particular teaching episodes and activities, they were able to make some connections between teaching and learning (Morris, 2006). Van Es and Sherin (2002) also provided evidence that the use of video excerpts can facilitate pre-service teachers' learning to notice important aspects of

practice. In addition, the presence of a critical friend or expert in the form of a lecturer or tutor can help to focus the ensuing discussion on important aspects of the lesson observed (e.g., Sherin, 2004).

Constructivism and Teaching for Understanding

Teaching in ways likely to develop students' mathematical understanding and that are consistent with a constructivist view of learning were central to the researchers' conceptualisation of effective teaching that underpinned the design and implementation of the course forming the context of this study. Constructivism does not provide a prescription for teaching but rather is a view of learning as "the process whereby individuals actively and purposefully modify, or if necessary completely change, their constructions in order to achieve an optimal fit with their experience" (Beswick, 2005, p. 42). Understanding is regarded as dynamic process whereby learners make connections between mathematical ideas and concepts on an ongoing basis (Pirie & Kieren, 1992). Pirie and Kieren (1994) identified four beliefs that teachers must have if they are to create learning environments that are consistent with constructivist principles, and in which mathematical understanding can develop. These were (1) that progress towards learning goals may not be achieved by all students nor in the expected way by all students, (2) there are multiple paths to a similar mathematical understanding, (3) different people can understand the same thing differently, and (4) there are different levels of understanding but there is no final endpoint to understanding a given topic. Although there is no definitive understanding of a topic that can be achieved and no set of things that a teacher can do to teach either for understanding or consistent with constructivism, it can be useful to identify features of teaching that are likely to facilitate students' development of understanding.

Teaching for understanding was one of eight principles of effective numeracy teaching identified by Muir (2008), in relation to which she sought to identify relevant teaching practices. She found that teachers' choice of examples and their use of representations were particular actions that could be useful in developing students' understanding, but that there were conditions under which the potential of each action was likely to be realised. Examples were effective when they helped students to make connections between mathematical topics. In the case of representations, it was important to consider not only materials used but also how and why they were used. Thus, although the teacher actions that Muir (2008) identified as contributing to teaching for understanding are observable, the caveats on their effectiveness demand a degree of judgement about the intention of the teacher as well as the responses of students. In identifying teaching likely to facilitate students' mathematical understanding it is not enough simply to observe what the teacher does. Santagata et al. (2007) suggested that pre-service teachers may not notice a recommended practice because they lack concrete images of what it looks like, but it is also possible that pre-service teachers form images of "good" practice based upon readily observable actions even though effective teaching is a far more subtle matter—as pointed out by Muir (2008) and others (e.g., Askew, Brown, Rhodes, Johnson, & Wiliam, 1997; Beswick, 2007; Watson & De Geest, 2005).

The pre-service teachers in this study had completed their initial two-week professional experience placement after just one semester of their course and the second after three. Although school placements early in teacher education courses provide an opportunity for pre-service teachers to assess their fit with the profession and could provide a point of reference for subsequent university study (although this seems to be largely ineffective—

see, for example, Lin, 2005; Taylor, 2002), it could also be argued that observing teaching at this stage, having had little opportunity to develop a critical framework through which to interpret the observations, could result in the formation of un-critiqued yet durable images of effective teaching.

Protocols for Viewing Videos of Teaching

Santagata et al. (2007) pointed to the need for studies of the use of videos in teacher education that document the effectiveness, in terms of pre-service teacher learning, of specific observation frameworks and protocols but relatively little has yet been offered to this end. One example is the study of Chval et al. (2009) who found that using prompts and focus questions when viewing the excerpts facilitated pre-service teachers' interpretation of them. The study reported here makes a further contribution to addressing this need. In particular the protocols used in this study were designed to be used by tutors in face-to-face classrooms, with a view to ensuring reasonable consistency between the experiences of different groups working with different tutors.

The protocol for one of the videos used is provided in Figure 1. It includes generic questions about teaching, such as "What would you do if you were the teacher conducting the lesson?" It also includes questions that are specific to the particular video and designed to draw pre-service teachers' attention to particular aspects of teaching; e.g., "What does Aaron's answer of 1.5 tell you about his understanding of decimals/decimal currency?" and "Are you convinced these students understand place value and the decimal system?" Furthermore, although not reported on in this paper, the protocol was intended to guide pre-service teachers studying online as they viewed the excerpts independently. The questions used to stimulate and guide discussion, including the times at which the videos should be paused and questions asked, were, therefore, specified in detail.

We were interested in the potential impact of video excerpts of teaching on pre-service teachers' learning in terms of their inclinations and abilities to identify and focus on the development of students' understanding of mathematics and the teaching and learning actions likely to facilitate this. In summary, our research was guided by the following questions:

1. What do pre-service teachers see as effective in another teacher's mathematics teaching practice as captured in a video excerpt?
2. What connections do they make between another teacher's mathematics teaching practice and their practicum experiences?
3. What are pre-service teachers' perceptions of the effectiveness of video excerpts in learning to teach mathematics?

In addition, the findings provided insights into pre-service teachers' widely documented preoccupations with classroom management as well as readily observable and largely superficial aspects of teaching (e.g., Beswick, 2006; Linares & Valls, 2009).

The Study

The study used a survey approach to obtain data in relation to each of the three research questions. In so doing, it relied on self reports of the participating pre-service teachers captured while, or immediately after, the video excerpts were viewed. The course that provided the context of this study was a four-year primary teacher education program leading to a

bachelor's degree in Education. It included a sequence of four half-units of mathematics curriculum, one in each of the four years. Each ran for one 13-week semester and involved a one-hour lecture and one-hour tutorial in each of the first three years and weekly two-hour tutorials in the final year. All classes, and particularly tutorials, were interactive with pre-service teachers engaged in solving mathematical problems and discussing pedagogical issues. The lecturers sought to model pedagogies consistent with a constructivist view of learning, and emphasised the importance of understanding as the basis of procedural efficiency and problem solving ability.

The video excerpts were designed to provide pre-service teachers with examples of real, local teachers engaged in exemplary mathematics teaching (in that it was consistent with the aims and constructivist underpinnings of the course), in an environment in which the pre-service teachers' observations could be guided by lecture and tutorial staff.

The Video Excerpts

The video excerpts, entitled *Making Connections* (V1) and *Teaching for Conceptual Understanding* (V2), used in the study featured the same secondary mathematics teacher with 20 years of teaching experience. During this time, he had been involved initially in undertaking and then planning and delivering professional learning for primary and secondary teachers of mathematics and was respected throughout the education system of Tasmania (Australia). He shared the lecturers' beliefs in the importance of teaching for conceptual understanding. The four students with whom he worked in both video excerpts were in Grade 8, and even though this is the second year of secondary school in Tasmania, his teaching uncovered shaky thinking about concepts that are central to the primary mathematics curriculum and hence were appropriate for the primary pre-service teachers. V1 ran for just under four minutes and focussed on place value concepts involving whole numbers to three digits. The teacher emphasised connections between the representations of numbers using icy-pole sticks (wooden sticks that can be readily bundled in groups of 10 or 100) and symbols. The excerpt included a discussion among the students of how an infinite number of numbers could be represented with just ten symbols.

The second video excerpt, V2, with duration of approximately 10.5 minutes, dealt with the extension of place value ideas from whole numbers to tenths. In this excerpt the teacher used icy-pole sticks to demonstrate bundling with tens, hundreds and thousands, and then asked a student to cut one of the sticks to represent tenths. The student roughly cut the stick into ten pieces and the ensuing discussion centred on the need or otherwise for the pieces to be the same size, and the position of the decimal point.

Both lessons were unscripted, and in both the teacher was explicit about his instructional decisions. For example, in both excerpts he stated that the students' responses had caused him to rethink and to change what he had planned to do, and in *Teaching for Conceptual Understanding* (V2) he explained to the students the importance he placed on making connections with their existing knowledge and establishing that they genuinely understood.

Participants

Pre-service teachers in the second year of the program provided data for the study. The pre-service teachers watched two different video excerpts during tutorials in two non-consecutive weeks of the second of the program's four

half-units of mathematics curriculum. The pre-service teachers had completed two practicums totalling five weeks; a two-week block in the first year of the program, and three-week block in the second year, in which they progressed from working with small groups of students to taking sessions with a whole class.

The numbers of pre-service teachers who contributed data in relation to each of the two video excerpts are shown in Table 1. Since the pre-service teachers who watched the two videos were the same cohort, there would have been considerable overlap between the two groups.

Table 1
Summary of Participant Numbers by Video Watched

Group	Number	Video Watched
G1	78	Making Connections (V1)
G2	98	Teaching for Conceptual Understanding (V2)

Instruments

After each of the videos had been shown during the relevant classes, the students completed a video-observation pro-forma, and the tutor was interviewed. Further, the researchers made some tutorial observations.

Video observation pro-forma. A video-observation pro-forma was used to obtain data on what the pre-service teachers had noticed and attended to in their watching of the video excerpts. The sections of the pro-forma relevant to this study asked pre-service teachers to, in writing: identify the focus of the teaching shown in the video excerpt and aspects of the of teacher's practice that they deemed effective; list any questions that they would ask the teacher; describe any aspect of the teaching that they would have handled differently, and what they would do next; compare the videoed teaching with that observed during professional experience in schools; and to indicate the extent to which it contradicted or confirmed their existing beliefs about effective mathematics teaching.

The final section of the pro-forma was designed to assess the pre-service teachers' perceptions of the value of video excerpts as a teaching tool. It comprised six items requiring responses on five-point Likert scales, and two open-response items asking (a) about the extent to which they believed the videos stimulated discussion, and (b) for suggestions concerning how video excerpts of teaching might best be incorporated in the unit.

No identifying information was requested.

Interview with tutor. The tutor who had conducted most of the tutorials participated in a brief semi-structured interview in which he was asked for his impressions of the effectiveness of the video excerpts as a teaching tool.

Tutorial observations. The authors each observed at least one tutorial in which the video excerpts were used.

Procedure

The video excerpts were shown to the second year cohort in the weeks in which they considered the development of whole number place value, and then the extension of these ideas to decimals. In both cases the one-hour tutorial time was devoted to working with the video excerpt. Discussion occurred throughout the excerpt, with the tutor stopping the video at key points in accordance with an observation protocol comprising guiding

questions, drawing the pre-service teachers' attention to key aspects, and eliciting their responses. The protocol for V2 is provided in Figure 1. The pre-service teachers were able to complete the video observation pro-forma throughout the tutorial and were given a few minutes at the end to finalise their responses. The pre-service teachers were informed that the completed pro-formas would be used to research the effectiveness of the video excerpts.

Guiding Questions: Teaching for Conceptual Understanding (Video 2)

When viewing the video excerpt, pause the footage at the designated times on the counter below (verbal prompts have been included to provide an additional guide as to when to pause the video). Discussion questions have been provided to prompt you to think further about what you have observed.

Video counter	Verbal prompt	Discussion questions
35:43	"connecting the new with the old"	What do you think the teacher meant by this? What prior knowledge would you expect these students (Gr. 8) to have in relation to place value? What questions would you ask to establish students' understanding of place value? Why do you think it is important to identify students' current understandings of a concept?
36:52	"equal parts – need to go back and do this properly"	What do you notice about the way the student (Jeb) is cutting the icy-pole stick? What does it tell you about Jeb's conceptual understanding of place value? What would you do if you were the teacher conducting the lesson? What other materials/aids could you incorporate to facilitate Jeb's understanding?
38:08	"is it important that all the group sizes are the same when we write a number like that?"	What did the teacher say/do to emphasise the importance of equal group sizes? Do you think this was effective in helping the students to understand?
39:50	"write that on your pad. One dollar, five"	(Here the teacher has picked up on a student's question and this has led the discussion into a different area) How would you capitalise on this 'teaching moment' to draw the links between decimals and money?
40:08	"So have you written the same amount of money?"	What does Aaron's answer of 1.5 tell you about his understanding of decimals/decimal currency?

42:07	"So what's that—that piece there? (points to part of stick) (Jeb) Five cent coin"	Why do you think Jeb interpreted the 'piece' as a five cent coin? What would you do to address this misconception?
End of video		Are you convinced that these students understand place value and the decimal system? What subsequent teaching decisions would you make based on your observations of what occurred in this lesson?

Figure 1. An example of a video pro-forma (Video 2).

The interview with the tutor took place in the week following his final use of the video excerpts in teaching and took approximately 15 minutes. During tutorial observations the researchers made notes of incidents that appeared to relate to the research questions.

Data Analysis

Data analysis occurred after the completion of the entire study. Pre-service teachers' responses to each question on the pro-formas were classified according to themes that were apparent in the data. For each question, this process involved reading the responses, postulating categories into which the responses could be coded, initial coding according to these categories, modifying and/or adding categories to better fit the data, and then re-coding of the data. Responses to some questions included aspects of more than one category that emerged for that question, so these responses were coded into more than a single category. For example, the response "Questioning—checking for understanding" was coded in both *Questioning and Teacher checking students' understanding before moving on*.

The two authors and a research assistant (a mathematics teacher and doctoral student in mathematics education) considered the data and made initial independent suggestions concerning categories. These were discussed at a meeting leading to an agreed set of categories. The research assistant then used the categories to code a sample of the data, following which the authors reviewed the coding, separately and then together with the research assistant. This resulted in further refinement of the categories.

The entire data set was then coded by the research assistant according to the revised categories. At this stage, each of the authors independently coded some of the data as a further check on reliability. The percentages of responses in various categories have been rounded and hence not all total exactly 100.

Results and Discussion

In the following sections, data related to each of the research questions are presented and discussed.

Research Question 1

Research question 1 was "What do pre-service teachers see as effective in another teachers' practice as captured in a video excerpt?" Table 2 shows the responses of pre-service teachers to the question, "What is the main purpose of this lesson phase?" "Place value" was considered a reasonable response in relation to both video excerpts, whereas "Decimals" was an appropriate response only in relation to V2. In each case approximately 80% of the cohort identified an appropriate purpose. Responses judged inappropriate tended to be statements of general nature that did not identify the topic. One such response was, "Show that mathematics is a more efficient way to work things out than individual counting". Such responses are not necessarily incorrect but didn't identify the specific mathematical focus.

Table 2
Identification of main purpose of the lesson phase shown in video excerpt

	G1 n=78 Number (%)	G2 n=98 Number (%)	Total n=176 Number (%)
Place value	63 (81)	65 (66)	128 (72)
Decimals	0 (0)	14 (14)	14 (8)
Not place value or decimals	15 (19)	19 (19)	34 (19)

Table 3 shows the pre-service teachers' responses to, "Identify three aspects of the teachers' practice that you see as being effective", in order of frequency of mention overall. The number of mentions of each aspect and the percentage of the pre-service teachers who mentioned each aspect are provided, along with examples that represent the types of responses in each category. Smaller numbers of pre-service teachers provided responses that fell into four other categories. These categories *Small group setting* (7 comments: 5 from G1 and 2 from G2); *Use of real life links*, and *Re-stating/reinforcing student comments/understandings* (in each case 6 comments: 4 from G1 and 2 from G2); and *Providing opportunities for visualisation* (4 comments: 3 from G1 and 1 from G2). A category, "Other", included diverse responses that attracted no more than three similar responses from either group. Although there were differences between the groups, the top six aspects of the teaching shown were the same in both cases. The most commonly cited aspect, the use of concrete materials and/or hands-on activity, comprised close to one quarter of the all aspects identified. It was mentioned by almost two thirds of the pre-service teachers.

Table 3
Aspects of the Teachers' Practice Identified as Effective

Aspect of teaching	Examples of responses	G1 n=78 No. (%)	G2 n=98 No. (%)	Total n=176 No. (%)

Use of concrete materials, hands on, kinaesthetic	Using manipulatives; Having concrete materials to explain what he is talking about; Using models—icy-pole stick bundles.	51 (65)	58 (59)	109 (62)
Scaffolding by the teacher	Scaffolding; Scaffolding—zone of proximal development; Checking on prior knowledge and understanding; Building from what they already know/scaffolding.	17 (22)	69 (70)	86 (49)
Use of questioning	Questioning—checking for understanding; Questioning of students; Questioning techniques.	39 (50)	36 (37)	75 (43)
Allowing student sharing/contributions	Including all students; Asking students to express their ideas; Letting students discuss their ideas and use those discussions to help their own understandings.	43 (55)	17 (17)	60 (34)
Learner/student centred	… students' questions lead the discussion; Pushing students to make understanding …and to find answers; Asking each student if they agree or what they think …	14 (18)	8 (8)	22 (13)
Teachers' adaptability/flexibility	Changing the lesson to suit the students' questions and understandings; Ability to be flexible and go with what comes up; Flexible.	11 (14)	8 (8)	19 (11)
Emphasis on justifying/explaining thinking	Getting students to elaborate on their responses; Asking the student to explain their thinking; Questioning/asking for examples and explanations.	10 (13)	7 (7)	17 (10)
Checking understanding before moving on	Discussion to develop a basic understanding … before moving on…; Going over ... to be assured they understand.	6 (8)	8 (8)	14 (8)
Focus on the meaning of symbols	Write the numeral down and then represent it, the discussion of the number of numerical symbols; Talking about symbols; … ten symbols make infinite numbers.	8 (10)	1 (1)	9 (5)

Personal qualities of the teacher	Patience—waits for students to answer and doesn't put words in their mouth; Used positive and [encouragement] to support them—but wasn't phony; Positive attitude.	7 (9)	2 (2)	9 (5)
Use of examples	Giving students examples—getting students to deconstruct the numbers; Use students' examples; Used lots of examples ...; allowing students to gain confidence …	1 (1)	8 (8)	9 (5)
Total numbers of aspects mentioned		234	244	478

We were particularly interested in the extent to which the pre-service teachers focussed on aspects that could be interpreted as relating directly to an emphasis on teaching for understanding because this was an underlying emphasis in all of the mathematics curriculum units in the course. Categories judged to have this focus have been italicised in Table 3 and also included the six comments in the category *Re-stating/reinforcing student comments/understandings* not shown in Table 3. As is evident from the examples provided in Table 3, responses that include (or might include) this focus are also found in other categories for several reasons. First, a single response might contain elements of more than one aspect and hence have been coded in more than one category. For example, "Building from what they already know/scaffolding" was included in the *Scaffolding* category but unpacks the idea of scaffolding in a way that suggests its role in teaching for understanding. Second, categories were not considered to emphasise teaching for understanding unless that emphasis was clear across all of the responses coded into it. Almost all of the categories could be associated with teaching for understanding but many were not included in the set identified as having a focus on teaching for understanding because most of the responses in these categories did not suggest unequivocally such a focus. Given existing evidence of pre-service teachers' tendency to focus on superficial features of teaching (e.g., Beswick, 2006; Linares & Valls, 2009), this conservative approach was appropriate because it mitigated against too readily ascribing benefits in terms of altering this tendency to the use of video excerpts as described here.

Notwithstanding our efforts, described above, to take a conservative approach to defining individual responses and hence categories of responses that reflect an emphasis on teaching for understanding, we acknowledge that our decisions are contestable. The judgements required are necessarily subjective to some extent and a matter of interpretation based upon our own experience and overall view of the situations shown in the video excerpts. For example, among the responses shown in Table 3 in the category "Teacher checking students' understanding before moving on", "Asking if the children understand …" could be done in an rhetorical way with no expectation on the part of teacher or students of an answer in the negative, regardless of what is actually the case. Similarly, the category, "Re-stating/reinforcing student comments/understandings" could be interpreted as a controlling move on the part of the teacher. In both cases we interpreted these as focussed on student understanding. Issues in this kind are common to any research in which inferences are made. (Chick [2011] describes this kind of

research dilemma in some detail.) This study did not allow such subtleties to be explored but there would undoubtedly be value in doing so. In terms of the use of video excerpts in pre-service teacher education, detailed discussion of the reasons behind pre-service teachers' interpretations of teacher actions shown in video excerpts presents an invaluable opportunity to develop the sophistication of pre-service teachers' thinking about teaching.

Half of the group who watched V1 (G1) and 26% of the group who watched V2 (G2) identified at least one aspect of the teaching that fell into this group of categories. Nevertheless, readily observable and arguably superficial features of teaching that may or may not contribute to the development of students' understanding were more frequently identified and thus appeared to be the primary focus of the pre-service teachers' attention. Effective teaching encompasses more than teaching for understanding, including engaging students and establishing positive classroom norms. Aspects of these were evident in responses in the categories, *Allowing student sharing/contributions*, *Learner/student centred*, and *Use of examples*. Overall though, the data suggest that many of the pre-service teachers in this study were able to see beyond the surface features of teaching.

The questions that the pre-service teachers suggested they would ask of the teacher provide further insights into the extent to which pre-service teachers focus on superficial aspects of teaching. Table 4 shows numbers of questions that the pre-service teachers suggested they would ask the teacher about the teaching they had just watched in each subject category that emerged from their responses.

Table 4
Subjects of Questions Suggested by Pre-service Teachers

	G1 (n=60) No. (%)	G2 (n=63) No. (%)	Total (n=123) No. (%)
Students' understanding	9 (14)	19 (24)	37 (21)
What next?	13 (20)	13 (16)	32 (18)
Group size including applicability to whole class setting	11 (17)	8 (10)	26 (15)
Changing the plan/original plan	10 (15)	8 (10)	18 (10)
Value of lesson	5 (8)	4 (5)	10 (6)
Use of concrete materials	2 (3)	5 (6)	8 (4)
Inclusivity/student engagement	1 (2)	5 (6)	7 (4)
Other	15 (23)	17 (22)	40 (22)
Total numbers of questions	66	79	178

In contrast to the data shown in Table 3, the most common focus of the pre-service teachers' questions, although comprising only one fifth of all questions suggested, was the students' understanding. This was particularly so in relation to the video excerpt, V2, in which students' misconceptions were most apparent. Typical questions included the following:

> How can you be sure the children who were unsure about number of symbols actually understand and are not just agreeing with the other student? (G1)

> Do you think this understanding is heightened by using visual tools (icy-pole sticks)? Can it be confusing for them? (G2)

Many pre-service teachers were also interested in finding out about where the teacher would next take the group, how the practice that he used in a small group context may or may not transfer to a whole class context, and why and how he changed his original plan. For example they suggested the following the questions:

> What would you do in the next phase of this lesson sequence? (G2)

> Would you teach this in a whole class situation or just small groups? (G1)

> You said you changed your mind about what to teach. What did you have in mind about the group to begin with, and what made you change your mind? (G1)

Morris (2006), in her study of beginning pre-service teachers' skills in analysing videos of teaching, reported the difficulty they had with citing evidence in support of their analyses. In this study the data presented in Table 3 provide a conservative estimate of the extent to which pre-service teachers focussed on substantial teaching and learning issues and the data in Table 4 suggest stronger concern with students' understanding. Thus, rather than pointing to relative disinterest in students' understanding, these pre-service teachers may have had similar difficulty to the pre-service teachers in Morris's study in identifying evidence of the students' understanding, as well as of teaching actions designed to elicit such evidence. The most commonly nominated aspects of effective practice listed in Table 3 may have been assumed by the pre-service teachers to contribute automatically to students' learning and understanding. Focussed discussion of the bases on which these things are judged effective would be useful in determining the extent to which this is the case. It might also provide a useful entry point into making explicit the kinds of evidences of understanding that teachers can look for and use in determining the progress of a lesson in terms of developing students' understanding.

Research Question 2

Research question 2 was "What connections do pre-service teachers make between videos of teaching and their practicum experiences?" The pre-service teachers were asked about the extent to which the video excerpts mirrored what they had seen on professional experience in schools.

In many cases (21% of those in G1 and 33% of those in G2), it was difficult to determine whether the pre-service teachers' responses were describing elements of the teaching that they regarded as similar to or different from the teaching they had observed during practicum weeks. For those who did respond clearly, the proportions describing the teaching in video excerpts as similar and different were essentially the same for both groups. Specifically, of the 62 (79%) pre-service teachers who watched V1 (G1) and responded clearly to the question, 39 (63%) indicated that the teaching shown in the excerpt was similar to that which they had seen on professional experience and 23 (37%) indicated that it was different. For the 66 (67%) pre-service teachers who watched V2 (G2) and made a clear response to this question, 40 (61%) indicated that the teaching shown was similar to that which they had seen, and 26 (39%) considered it different. The difference in proportions of non-response or unclear response between the two groups may be due to the differing content of video excerpts. V1 depicted teaching of whole number place value whereas V2 showed teaching of decimal place value, so the difference could reflect the fact that

the pre-service teachers had completed their professional experience placements in primary schools in which they would have been unlikely to have seen decimal place value taught except in the highest grade levels. They would have been much more likely to have seen lessons on whole number place value as well as the use of icy-pole sticks and similar materials.

Forty six (36%) of the 128 pre-service teachers provided a response to the question about ways in which the teaching shown in the video excerpts differed from that observed in schools. The responses were classified according to whether they related to specific aspects of the particular lesson such as the topic or the particular materials, or to more general pedagogical principles. Typical examples of differences relating to specific aspects included:

> Many teachers expect all their students to already know place value. (G1)
>
> Personally, I haven't experienced practical teaching situations of decimal numbers. However this video example provided an effective example for how to assist students in understanding place value. (G2)

Typical examples of differences concerning more general aspects of pedagogy included:

> The teaching allowed for student interaction to create understanding. (G1)
>
> He was using all different learning ways in his teaching, visual, kinaesthetic, and aural. (G2)
>
> Different as most maths I've seen in prac has come from worksheets. Good to see a practical lesson with children. (G2)
>
> I have not seen any explicit teaching like this. There were no conceptual understanding lessons, no explicit teaching at all. (G2)

Pre-service teachers who indicated that the video excerpt was similar to teaching they had observed were far less likely than those who said it was different to provide a reason for their assessment. Specifically, just seven of the 79 (9%) who considered the teaching similar provided a reason whereas 39 of 49 (80%) who considered it different offered a reason. Of the seven reasons provided for saying the teaching was similar, four related to specific aspects of the lesson and three to more general pedagogical aspects. For those who considered the videoed teaching different from their experiences, 16 (41% of those who provided reasons) suggested specific aspects while 23 (59%) offered reason focussed on general pedagogy. These numbers are small and hence need to be interpreted cautiously. They do, however, suggest a possible tendency for pre-service teachers who noticed differences to focus on broader aspects. The fact that many more of those who reported difference from their experience provided reasons at all further supports an inference that these pre-service teachers might have reflected more carefully on the teaching shown in the video in relation to their previous experience.

Many pre-service teachers commented on the fact that the video showed a group of four students rather than a whole class, and so responses related to this specific feature of the lesson were placed in a separate category. These data are shown in Table 5 in which the percentages relate to the total numbers of differences noted. The data for the two groups are similar except that more of the cohort who watched V1 (G1) suggested specific aspects of the lesson, whereas those watching V2 were more likely to nominate aspects that did not fall clearly into any of the categories and hence were classified as Other.

Eighty three percent of G1 and 64% of G2 responded to the question, "Did the video confirm or contradict what you believe to be effective

mathematics/numeracy practice? In both cases all but two of these pre-service teachers indicated that the video excerpt confirmed their beliefs. Just one pre-service teacher, who watched V1 suggested a contrary position and the remaining three indicated that they were unsure. Unfortunately the one who indicated that the video excerpt contradicted his/her existing beliefs did not provide a comment about the how or the extent to which this was the case. That the videos were overwhelmingly perceived to confirm the pre-service teachers' beliefs is unsurprising given that the teacher in the excerpts was selected because he was considered likely to demonstrate the kinds of mathematics teaching advocated in the course.

Table 5
Ways in Which Pre-service Teachers Perceived the Videoed Teaching to Differ from that Observed on Professional Experience

	G1 (n=63) No. (%)	G2 (n=75) No. (%)	Total (n=138) No. (%)
Focus on specifics of lesson	18 (29)	14 (19)	32 (23)
Focus on broader pedagogical principles	36 (57)	43 (57)	79 (57)
Focus on group size	7 (11)	6 (8)	13 (9)
Other	2 (2)	12 (16)	14 (10)
Total numbers of differences	63	75	138

Of more interest are the aspects of the teaching that the pre-service teachers mentioned when they considered the extent to which it confirmed or contradicted their existing beliefs. Forty four percent of G1 and 40% of G2 provided comments about this. The numbers and percentages of their comments that related to various aspects of the videoed teaching are shown in Table 6. The most commonly cited aspect of teaching was the use of hands-on materials followed by unspecified references to effective practice.

Table 6
Aspects of Teaching Considered in Comparing Videoed Teaching with Own Beliefs

	G1 (n=34) No. (%)	G2 (n=39) No. (%)	Total (n= 73) No. (%)
No aspect specified	44 (56)	59 (56)	103 (56)
Showed benefits of concrete/hands on materials	10 (13)	12 (11)	22 (12)
Showed effective practice	8 (10)	7 (7)	15 (8)
Showed good teacher scaffolding	1 (1)	6 (6)	7 (4)
Showed benefits of small groups	3 (4)	1 (1)	4 (2)
Showed peer /discussion	4 (5)	2 (2)	6 (3)
Other	9 (11)	18 (17)	27 (15)
Total numbers of comments	79	105	184

The following comments illustrate each of the categories in Table 6 in the order in which they appear there:

> It confirmed that the use of concrete materials is crucial in developing new ideas. (G2)

> Confirm, and showed effective practice. (G2)
>
> Confirm what I believe is effective. Teacher scaffolds with students for them to develop their understanding. They are allowed many different stimulus/materials in order to further understanding. There is time to reflect/consolidate. (G1)
>
> Working in small groups and holding discussions is effective. (G1)
>
> Great direction of students' learning, and conversations, thus allowing for effective peer scaffolding. (G2)
>
> It confirmed my beliefs. He also realised that he needed to adapt his lesson as he found out the children's thoughts which is good, teachers need to constantly do this. (G1)

The prominence of comments about the use of concrete materials is consistent with the fact that this readily observable aspect of the teaching shown in the video excerpts was also most likely to be nominated by pre-service teachers as contributing to the effectiveness of the teacher's practice (Table 3). The use of hands-on materials was also the most commonly cited aspect of the mathematics curriculum units in an earlier but similar iteration of the same teacher education program that second and third year pre-service teachers had nominated as most valuable to their own learning (Beswick, 2006). We do not know from this study the extent to which the pre-service teachers regarded concrete materials as inherently beneficial in mathematics teaching or were aware of the importance to their effectiveness of how and why they are used as discussed by Muir (2008). To the extent that the former was the case there may be a need to assist pre-service teachers to shift the focus of their attention (Mason, 1998) from the impact of the use of concrete materials on their own understandings of fundamental mathematical ideas to seeing them as possible tools to help students to develop their mathematical understandings and hence to value concrete materials if and to the extent that they contribute to this end.

Because we are attuned to notice certain things as a result of the sum of our experiences to date (James, 1890, cited in Mason, 2005), we are more likely to notice that which confirms our existing beliefs. It is unsurprising, therefore, that almost all pre-service teachers who provided a clear indication one way or the other reported that the video excerpts confirmed their existing beliefs about mathematics teaching and learning. It would be interesting to unpack in much more detail than was possible in this study exactly what about the teaching depicted in the excerpts was interpreted as confirmatory of the pre-service teachers' existing beliefs. Evidently, there were some things that confirmed their beliefs and yet were also perceived as different from their experiences. It thus seems that their image of good teaching included more than that which they had observed in either their own schooling or during initial professional experience placements in schools.

Research Question 3

Research question 3 was "What are pre-service teachers' perceptions of the effectiveness of video excerpts in learning to teach?" Observational data indicated that the video excerpts were useful teaching tools, and provided for discussion of effective mathematics teaching. In order to fully answer the third research question, however, data were also gathered about the pre-service teachers' perceptions of the usefulness of the excerpts. These data were obtained from the second part of the pro-forma that focused on the pre-service teachers' evaluations of video excerpts as a teaching tool. Table 7

shows pre-service teachers levels of agreement with the six items requiring responses on Likert scales. The results were very similar for both groups of pre-service teachers so the numbers and percentages for both have been combined.

Table 7
Levels of Agreement with the Usefulness of the Video Excerpts (n=176)

Statement	Strongly Disagree No. (%)	Disagree No. (%)	Neutral No. (%)	Agree No. (%)	Strongly Agree No. (%)
Provided good examples of mathematics/ numeracy practice	2 (1)	0 (0)	13 (7)	115 (65)	46 (26)
Increased my understanding of what effective mathematics/ numeracy practice looks like	3 (2)	1 (1)	25 (14)	109 (62)	38 (22)
Provided a link between theory and practice	2 (1)	0 (0)	8 (5)	133 (76)	33 (19)
Provided me with useful strategies to use in the classroom	0 (0)	4 (2)	21 (12)	110 (63)	39 (22)
Been useful to my future teaching career	3 (2)	3 (2)	17 (10)	127 (72)	11 (6)
Enabled me to reflect on my own teaching beliefs and practices	3 (2)	3 (2)	37 (21)	108 (61)	25 (14)

Table 7 shows that 91% of the pre-service teachers surveyed either agreed or strongly agreed that the excerpts provided good examples of mathematics/numeracy practice. This result was encouraging in that it supported the original aim of the researchers to provide examples of exemplary mathematics teaching practice. There were also high levels of agreement recorded for all the other statements, indicating that the pre-service teachers perceived the excerpts to be useful in stimulating them to reflect on their own teaching beliefs and practices as well as being valuable for their future work in classrooms.

In terms of usefulness, 93% rated the inclusion in their course of video excerpts of different teachers' classroom practice either Useful (50%) or Very useful (44%). This result needs to be treated cautiously, however, given the asymmetric nature of the scale used for this question that provided two positive options and just one negative choice. Responses to the open question about the extent to which the video excerpts stimulated discussion indicated that the pre-service teachers perceived them to be effective to this end. The following comments are illustrative:

> The video was stopped many times and it was good for us to be able to discuss certain points.

> Classroom discussion was extremely valuable throughout the video—without it I would have found myself not taking away the amount of knowledge I will now.
>
> People shared opinions, views, discussed effective teaching strategies, made clarifications.
>
> There was good discussion, especially when we paused the video and talked about what we were seeing and other ways we could teach the same thing.

This perception was supported by the tutor who was interviewed. He was positive about the fact that the level of discussion had increased with the use of the video excerpts and believed they had also prompted pre-service teachers who had not regularly contributed to group discussions before to articulate their opinions. He felt that the excerpts were effective in encouraging the pre-service teachers to question their own teaching practices, and to comment on practices they observed while on professional experience placements. He also felt the discussion enabled them to gain a greater understanding of teaching decisions that are made and enacted during the course of a lesson.

Fewer than half of the pre-service teachers offered suggestions about how video excerpts should be used in their course. Those who responded were keen to see more, and to have them used similarly to the way that occurred in this trial. That is, have excerpts that relate to the lecture topic, used so as to stimulate tutorial discussion, and assist them to consolidate their learning.

Conclusion

The data indicated that many of the pre-service teachers were interested in the development of students' understanding but that many struggled to identify evidence of it or observable teaching actions likely to contribute to it. More could be done both in terms of refining the protocol that was used in viewing the video excerpts and also in the course more generally, to assist pre-service teachers to develop the necessary skills to identify these aspects. The former could involve prompting for a more detailed analysis of and reflection on the possible purposes behind particular actions and utterances of the teacher, and of the mathematical understandings suggested by particular student responses. Pre-service teachers need guidance and practice at digging below the image of "good teaching" with which they enter teacher education or form shortly thereafter.

Chval et al. (2009) advocated the use of videos of teaching that counter pre-service teachers' experience and allow them to articulate *strong* opinions. In this study, the video excerpts were deliberately designed in accordance with Brophy's (2004, cited in Sherin et al., 2009) recommendation to assist the pre-service teachers to identify readily with the context. That is, they were set in a local school, and the teacher's accent, the appearance of the classroom, and the relevant curriculum were familiar to them. The video excerpts used in this study enabled the pre-service teachers to articulate firm opinions about teaching that were, in many cases, about practices that differed from their own experiences. The fact that in spite of this they still did not appear to challenge the pre-service teachers' beliefs in significant ways suggests that more than a context with which they can identify and the depiction of unfamiliar practice leading to the articulation of strong opinions is required.

We suggest that, in addition to the strength of opinions elicited, the depth of critique of those opinions that is prompted and the centrality of the beliefs that underpin them is perhaps what matters. The protocol used in this study was judged by the tutor and pre-service teachers to have been effective in generating discussion. This could be strengthened by the addition of prompts to deeper reflection and questioning of assumptions about such things as why hands-on materials are valuable would appear to be worthwhile. Discussions in which pre-service teachers are asked to cite specific evidence of claims that they make about the effectiveness or otherwise of observed teaching and learning activities and to articulate how these examples of practice challenge or confirm their existing beliefs would likely be effective. From a research point of view the inclusion of interviews in which written responses could be explored in greater depth could shed light on some of the issues raised by this study.

The use of video excerpts provides a context in which pre-service teachers can be prompted to reflect on their beliefs and this can lead to changes in line with course goals (Philipp, et al., 2007). This study was planned mindful of the need to direct pre-service teachers' attention to salient aspects of the videoed teaching. Nevertheless, the data suggest several factors that may have limited the success of the protocol that was used in terms of its effectiveness in prompting the type and depth of reflection we would like to see. These factors also suggest features of pre-service mathematics education programs that could usefully be modified.

The questions in the observation pro-forma that the pre-service teachers completed focussed on the teacher. The onus was on the tutor to use the Guiding Questions (see Figure 1) to direct the pre-service teachers' attention to the mathematics and the students' understanding of it. This is a demanding task made more difficult by the second contributing factor, namely that the pre-service teachers had had relatively little experience of analysing student work in terms of the understanding that it evidences. This was a major focus of the final half-unit of the course that the pre-service teachers had not yet done.

The findings of this study suggest that students' work and students' mathematical thinking could usefully be foundational to the entire mathematics education program that the pre-service teachers undertake. Furthermore, this should include specific focus on what constitutes evidence of understanding and how teachers can elicit such evidence from students. Santagata et al. (2007) demonstrated that pre-service teachers become more skilled at analysing videos of teaching given practice and appropriate protocols. The extent to which these skills translate to analysing actual teaching in the practicum context is yet to be examined but worthy of such examination.

The findings are encouraging in that they show that many pre-service teachers are interested in the development of students' understanding even if unsure of how to gauge it, and that the majority are also able to look beyond the specifics of the lesson observed to broader pedagogical principles. The challenge for the researchers and others involved in curriculum development in this context is to assist pre-service teachers to develop the skills needed to analyse teaching in ways that allow it to challenge their preconceived ideas and to reflect deeply on their own and others teaching practice.

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References

Askew, M., Brown, M., Rhodes, V., Johnson, D., & Wiliam, D. (1997). *Effective teachers of numeracy*. London: School of Education, King's College.

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

Beswick, K. (2005). The beliefs/practice connection in broadly defined contexts. *Mathematics Education Research Journal, 17*(2), 39–68.

Beswick, K. (2006). Changes in preservice teachers' attitudes and beliefs: The net impact of two mathematics education units and intervening experiences. *School Science and Mathematics, 106*(1), 36–47.

Beswick, K. (2007). Teachers' beliefs that matter in secondary mathematics classrooms. *Educational Studies in Mathematics, 65*(1), 95–120.

Blomberg, G., Stürmer, K., & Seidel, T. (2011). How pre-service teachers observe teaching on video: Effects of viewers' teaching subjects and the subject of the video. *Teaching and Teacher Education, 27*, 1131–1140.

Chick, H. (2011, November). *God-like educators in a fallen world.* Paper presented at the 2011 annual conference of the Australian Association for Research in Education, Hobart, Tasmania.

Chval, K. B., Lannin, J. K., Arbaugh, F., & Bowzer, A. (2009). Videos and prospective teachers. *Teaching Children Mathematics, 16*(2), 98–105.

Clark, J. C., & Walsh, J. (2002). Elements of a model of effective teachers. In P. L. Jeffrey (Ed.), *Problematic futures: Educational research in an era of uncertainty: Proceedings of the 2002 conference of the Australian Association for Research in Education* (pp. 1-11). Coldstream, VIC: AARE.

Lin, P.-J. (2005). Using research-based video-cases to help pre-service teachers conceptualize a contemporary view of mathematics teaching. *International Journal of Science and Mathematics Education, 3*, 351–377.

Llinares, S., & Valls, J. (2010). Prospective primary mathematics teachers' learning from on-line discussions in a virtual video-based environment. *Journal of Mathematics Teacher Education, 13*(2), 177-196.

Mason, J. (1998). Enabling teachers to be real teachers: Necessary levels of awareness and structure of attention. *Journal of Mathematics Teacher Education, 1*, 243–267.

Mason, J. (2005). Frameworks for learning, teaching and research: Theory and practice. In G. M. Lloyd, M. S. Wilson, J. L. M. Wilkins & S. Behm, L. (Eds.), *Proceedings of the 27th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 1–21). Roanoke, VA: Virginia Polytechnic Institute and State University.

Morris, A. K. (2006). Assessing pre-service teachers' skills for analyzing teaching. *Journal of Mathematics Teacher Education, 9*, 471–505.

Muir, T. (2008). Principles of practice and teacher actions: Influences on effective teaching of numeracy. *Mathematics Education Research Journal, 20*(3), 78–101

Philipp, R. A., Ambrose, R., Lamb, L. L. C., Sowder, J. T., Schappelle, B. P., Sowder, L., et al. (2007). Effects of early field experiences on mathematical content knowledge and beliefs of prospective elementary school teachers: An experimental study. *Journal for Research in Mathematics Education, 38*(5), 438–476.

Pirie, S., & Kieren, T. (1992). Creating constructivist environments and constructing creative mathematics. *Educational Studies in Mathematics, 23*(5), 505–528.

Pirie, S., & Kieren, T. (1994). Growth in mathematical understanding: How can we characterise it and how can we represent it? *Educational Studies in Mathematics, 26*, 165–190.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula, T. J. Buttery & E. Guyton (Eds.), *Handbook of research on teacher education* (2 ed., pp. 102–119). New York: Simon & Schuster Macmillan.

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.

Sherin, M. G. (Ed.). (2004). *New perspectives on the role of video in teacher education*. Oxford, UK: Elsevier.

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.

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

Star, J. R., & Strickland, S. K. (2008). Learning to observe: Using video to improve pre-service mathematics teachers' ability to notice. *Journal of Mathematics Teacher Education, 11*, 107–125.

Stein, M. K., Smith, M. S., Henningson, M. A., & Silver, E. A. (2000). *Implementing standards-based mathematics instruction: A casebook for professional development*. New York: Teachers College Press.

Taylor, P. M. (2002). Implementing the standards: Keys to establishing positive professional inertia in preservice mathematics teachers. *School Science and Mathematics, 102*(3), 137–142.

Van Es, E. A., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education, 104*(4), 571–596.

Watson, A., & De Geest, E. (2005). Principled teaching for deep progress: Improving mathematical learning beyond methods and materials. *Educational Studies in Mathematics, 58*(2), 209–234.

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