

Blomberg, Geraldine; Renkl, Alexander; Gamoran Sherin, Miriam; Borko, Hilda; Seidel, Tina
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Kontakt / Contact:

peDOCS
Deutsches Institut für Internationale Pädagogische Forschung (DIPF)
Mitglied der Leibniz-Gemeinschaft
Informationszentrum (IZ) Bildung
Schloßstr. 29, D-60486 Frankfurt am Main
E-Mail: pedocs@dipf.de
Internet: www.pedocs.de

Geraldine Blomberg, Alexander Renkl, Miriam Gamoran Sherin,
Hilda Borko & Tina Seidel

Five research-based heuristics for using video in pre-service teacher education

Abstract

This article provides a research synthesis on the use of video in pre-service teacher education. Common ideas and evidences concerning the use of video in pre-service teacher education are reviewed. Based on the state-of-the-art in using video, five research-based heuristics are derived. Research findings of a number of studies are further used to illustrate the specification of heuristics. Specifically, a set of rules of thumb about when, how, and why to use video is presented to clarify the strengths and limitations of video as a medium to support pre-service teacher learning.

Keywords

Teacher education; Video; Pre-service; Professional development

Geraldine Blomberg · Prof. Dr. Tina Seidel (corresponding author), TUM School of Education, Technische Universität München, Arcisstr. 21, 80333 Munich, Germany
e-mail: geraldine.blomberg@tum.de
e-mail: tina.seidel@tum.de

Prof. Dr. Alexander Renkl, Department of Psychology, University of Freiburg, Engelbergerstr. 41, 79085 Freiburg, Germany
e-mail: renkl@psychologie.uni-freiburg.de

Prof. Dr. Miriam Gamoran Sherin, School of Education and Social Policy, Northwestern University, 2120 Campus Drive, Northwestern University, Evanston, Illinois 60208, United States of America
e-mail: msherin@northwestern.edu

Prof. Dr. Hilda Borko, Graduate School of Education, Stanford University, 485 Lasuen Mall, Stanford, CA 94305-3096, United States of America
e-mail: hildab@stanford.edu

Fünf evidenzbasierte Heuristiken für den Einsatz von Video in der universitären Lehrerbildung

Zusammenfassung

Der Beitrag liefert eine Forschungssynthese zur Nutzung von Video in der universitären Lehrerbildung. Die Forschung wird dahingehend zusammengefasst, welche Ideen derzeit verfolgt werden und welche Evidenzen zur Nutzung von Video vorliegen. Basierend auf dem Forschungsstand leiten die Autoren fünf forschungsbasierte Heuristiken zum Einsatz von Video ab. Die Forschungsergebnisse einer Reihe ausgewählter Studien werden genutzt, um die Heuristiken weiter zu spezifizieren. Es werden Erfahrungsregeln vorgestellt, wann, wie und warum Video in der universitären Lehrerbildung eingesetzt werden kann. Die Erfahrungsregeln sollen helfen, Stärken und Schwächen von Video als ein Medium zur Unterstützung des Lernens von Lehramtsstudierenden zu klären.

Schlagworte

Lehrerforschung; Video; Universitäre Lehrerbildung; Professionelle Weiterbildung

1. Introduction

Many pre-service teachers struggle when they begin a teaching position – suffering from “practice shock” (Stokking, Leenders, de Jong, & van Tartwijk, 2003). Specifically novice teachers find it difficult to apply what they have learned in their teacher education program (Cochran-Smith & Zeichner, 2005). They tend to revert to intuitive theories of teaching and learning that correspond with their own experiences in school rather than with the research-based knowledge from their teacher education program (Lampert & Ball, 1998). In other words, their theoretical knowledge often remains inert (Whitehead, 1929); such knowledge can be retrieved when required, but it does not guide their classroom practice (Cochran-Smith, 2003). To address this limitation, teacher educators, administrators, and policymakers stress that teacher education needs to more effectively help future teachers to develop knowledge and skills in a way that can be applied in a classroom (Darling-Hammond & Bransford, 2005; Korthagen & Kessels, 1999). Specifically, many suggest that pre-service teacher education needs to strengthen the theory-practice connection (Feiman-Nemser, 2001; Grossman, 2005; Korthagen & Kessels, 1999).

To do so, Ball and Forzani (2009, 2010) argued for making practice the core of teachers’ professional preparation. But how should practice – which introduces professional teaching to novices – be used in initial pre-service teacher education? Grounding pre-service teacher learning in practice requires developing approaches that help pre-service teachers to learn in a contextualized way (Ball, 2000). Practice should be made visible to and learnable by novices (Feiman-Nemser,

2001). Integrating practice into teacher education programs might initially involve seeing examples of tasks, analyzing those tasks, seeing demonstrations, and, later on, seeing actual practice in classrooms (Ball & Forzani, 2009). Furthermore, grounding learning in practice should allow pre-service teachers to focus their attention on particular aspects of the work of teaching without reducing teaching practice to an atomized collection of unconnected, fragmented acts (Grossman et al., 2009).

One approach for grounding learning in practice has been the use of video in pre-service teacher education (Santagata, Gallimore, & Stigler, 2005). Given the fact that video is used intensively in this field, our research synthesis aims at both summarizing the state-of-art as well as providing some structure by means of heuristics for using video. In our approach, we used a synthesis strategy by first summarizing literature systematically and deriving heuristics (see Figure 1). Second, we enriched these heuristics by adding relevant literature in order to illustrate specific aspects to be taken into account in using video in pre-service teacher education.

In the first synthesis section, the data base Web of Science was searched for keywords such as classroom video, teacher education, pre-service teacher education, professional vision, video observation. In addition, relevant reviews and edited books on the topic of using video in the learning sciences, instruction and teacher education were summarized. In order to select publications, we focused on contents referring to the specific use of video and effects on pre-service teacher learning. We are aware that our synthesis is not inclusive regarding all empirical studies in this field, but we think that the selection gives a comprehensive overview of the different approaches and findings achieved. The approach chosen in this synthesis has limitations regarding the inclusiveness and the rigor of a quantitative and systematic research review. Given the fact that many studies in this field are based on qualitative approaches and case analyses, we think, however, that at this stage, we can better contribute to the important field by providing heuristics that might serve as a model or structure for future, more systematic research reviews.

2. Research-based heuristics for the use of video in pre-service teacher education

A look back at the history of research in teaching and teacher education shows that the use of video analysis has changed over time in line with technological developments (Sherin, 2004a). In particular, advances in digital videography, software development, and online tools have led to higher quality videos and, at the same time, greater accessibility, both of which have fostered a substantial increase in the use of video in teacher education (Goldman, Pea, Barron, & Derry, 2007; Hiebert, Gallimore, & Stigler, 2002; Krammer et al., 2006). In addition, the learning objectives involved when using video have broadened over time from goals related primarily to learning specific instructional techniques to goals related to strengthen-

ing a teacher's content knowledge and developing reflective knowledge of teaching and learning (Rich & Hannafin, 2009; Santagata et al., 2005).

But what is it about video that makes it so valuable for learning to teach? A range of researchers have argued that several features of video promote meaningful learning opportunities in teacher education, and in particular, may help to guide pre-service teachers to activate, acquire, and apply knowledge in a meaningful way (Abell & Cennamo, 2004; Brophy, 2004; Goldman et al., 2007). First, video has the potential to make practice accessible in manageable-sized chunks (Le Fevre, 2004). For example, portions of a video-taped lesson can be viewed repeatedly to allow pre-service teachers to reflect on the lesson from multiple points of view (Spiro, Collins, & Ramchandran, 2007). The fact that video offers pre-service teachers a "window" into teaching without the pressure of having to interact in the classroom situation is critical (Sherin, 2004a). Having to respond immediately to a teaching situation as is required during instruction can put a great deal of stress and pressure on novices and may interfere with their learning. Second, pre-service teachers typically perceive video as a vivid second hand experience, one that captures the complexity of classroom situations (Miller & Zhou, 2007). In addition, video facilitates learning in a way that is thought to be of great interest to pre-service teachers (Lampert & Ball, 1998). Viewing teaching via video is generally quite motivating and compelling for pre-service teachers (Areglado, 1999; Roth, 2007).

In addition to these claims about the affordances of video for teacher learning, some experimental studies have demonstrated that video bridges the gap between theory and practice and supports pre-service teachers' attempts to apply what they have learned at the university in actual classroom lessons. For example, elementary education students were found to score significantly higher on a test of content knowledge and on the assessment of observation skills after using interactive videodisc materials than after using written material (Carlson & Falk, 1990). In other work, Overbaugh (1995) looked at how the use of video materials affected what pre-service teachers learned about classroom management. He found a significant difference in achievement from pre- to posttest with regard to students' knowledge and concerns about teaching. In another study, Kinzer and Risko (1998) implemented multimedia cases into their pre-service classes and found that these led pre-service teachers to more increasingly refer to those cases/problems when teaching in practicum classes in contrast to before using multimedia cases. The teachers also faced classroom challenges more successfully and reacted more flexibly to unexpected situations in class. In addition, Ferdig, Roehler, and Pearson (2001) found that a video-based framework (the Reading Classroom Explorer) significantly improved pre-service teachers' deep understanding of teaching and learning and resulted in pre-service teachers to successfully relate what they learn at university to their experiences outside of class such as internships. Furthermore, videotaped demonstrations were found to be superior in eliciting competent instructional implementation of certain techniques to improve reading comprehension compared to role-play simulations (Anderson, Frager, & Boling, 1982). Above that, a recent meta-analysis reviewed the effect of video-feedback in education and

teaching and showed that video-feedback in general had a strong impact on professional interaction skills (Fukkink, Trienekens, & Kramer, 2011).

These studies notwithstanding, the empirical literature supporting the effectiveness of using classroom video in pre-service teacher education (especially in terms of controlled experimental design studies) is relatively thin. Also, some studies contradict the findings discussed above about videos' effectiveness (Barker, 1988; Fuller & Manning, 1973; Schrader et al., 2003; Winitzky & Arends, 1991). We believe that these contradictory findings result, in part, from differences in the goals for video-based activities and the ways in which the tool video is used in pre-service teacher education. In some cases, videos of whole lessons are used (McDonald, 2010; Rosaen, Lundeberg, Cooper, Fritzen, & Marjorie, 2008; Santagata, Zannoni, & Stigler, 2007) while in others, the focus is on shorter clips (van Es & Sherin, 2002). The type of video material used also varies – examples of best teaching practices rarely observed in regular classrooms (Lampert & Ball, 1998; Seago, 2004), examples of typical classroom lessons (Clarke et al., 2008), or examples of the pre-service teachers themselves during their first teaching experiences (Santagata & Guarino, 2011). Furthermore, there are programs that use video in order to develop pedagogical skills independent from specific disciplines among pre-service teachers such as understanding student thinking or reflective practice (Marsh, Mitchell, & Adamczyk, 2010; Masingila & Doerr, 2002; Sharpe et al., 2003; Stockero, 2008). Other programs emphasize the development of teachers' understanding of particular subject areas (Linares & Valls, 2009; Schrader et al., 2003; Wong, Yung, Cheng, Lam, & Hodson, 2006).

Unfortunately, most reports provide little detail concerning how video is used exactly in teacher education activities. Hence, the principles behind the different video applications remain unclear. Specifically, the use of video is mostly described in quite general terms; when in fact, it is the details of how video is integrated into instruction that seem to determine its effectiveness. These details are particularly important given recent research which stresses that video should be regarded as neutral in character – as a tool (van Es, 2009). As Brophy (2004) clarified, video should be considered as a technology for delivering content, not as a body of content itself. Thus, elements of teacher education programs that use video should be understood to be a curricular component and not the curriculum itself (Seago, 2004). Furthermore, video, and learning activities that incorporate video, should be regarded with reference to the major purposes of the teacher education program in which they are used. Along these lines, Krammer and colleagues (2006) emphasized that video only realizes its full potential in well-conceptualized learning environments. Despite these claims, there is little research on how to use video in order to systematically support the learning of pre-service teachers.

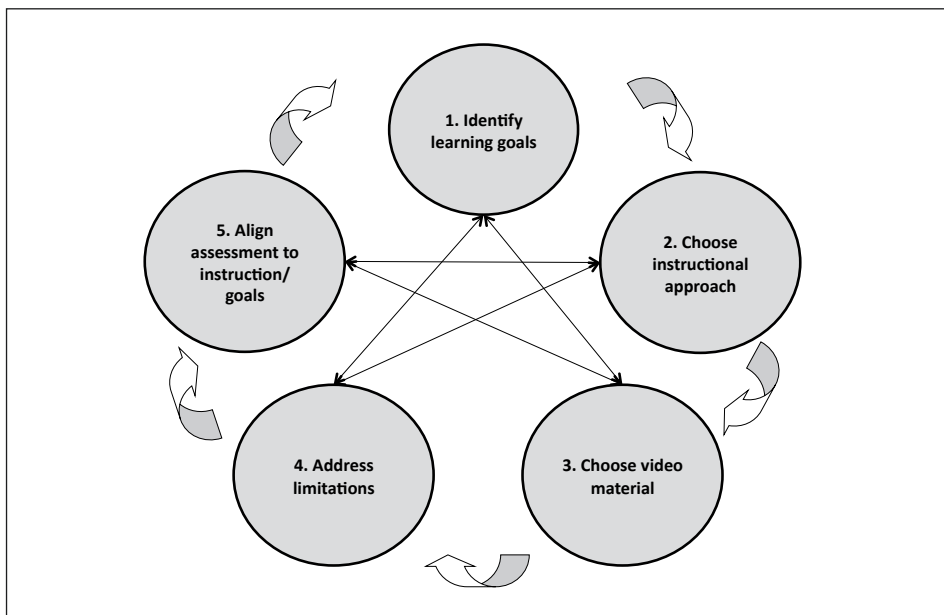
To address this issue, five research-based heuristics are offered regarding the specific use of video in pre-service teacher education. A variety of perspectives on the role of video in teacher learning is summarized – not only from international points of view, but also in using video with pre-service teachers in decidedly different ways. The focus of this article is on pre-service teacher learning because the

lack of empirical evidence is particularly apparent in this field. However, many of the approaches presented here are relevant for in-service teacher learning as well.

Given this state of art, five research-based heuristics concerning how to think about and use video in order to create well-conceptualized learning environments can be distinguished. Each heuristic requires specific decisions to be made in order to create an effective learning environment.

1. As a first step in designing video-based activities, it seems important to think about which learning goals are pursued.
2. Then, an activity to be aligned with those goals should be designed. In this regard, it seems important that video has to be conceptualized as a technological tool and systematically embedded by appropriate instructional strategies.
3. Once learning goals and the instructional approach are set, careful decisions are required about what kind of video materials are needed. Therefore, different kinds of video material one might use when fostering teacher learning have to be considered, such as video of one's own teaching versus a colleague's teaching. Different video materials offer different strengths.
4. Thus, teacher educators should be aware about the strengths and limitations of the use of video in pre-service teacher education and stress the importance of addressing limitations.
5. Finally, it seems important that, when using video, aligning the way learning is assessed to the way learning is fostered increases the learners' motivation as well as strengthens the efficacy and accuracy of video-based learning environments.

Figure 1: Research-based heuristics of using video in pre-service teacher education



These five heuristics can be understood as sequential steps in using video in pre-service teacher education. However, in the actual practice of implementation, the steps will often turn out to demand cyclical decisions. Figure 1 illustrates the complex design space in the decision process of using and selecting video. After outlining each heuristic and its empirical evidence, rules of thumb meant as decision aids for optimal application of the guidelines in specific situations are derived.

3. Illustration of research-based heuristics

3.1 Identify specific learning goals

When integrating video into learning environments for pre-service teacher education, it seems to be important to specify the main learning goal for using video with pre-service teachers and to align the video-based activities to that goal. There is a diversity of learning goals that are particularly well-suited for the use of video, and others that might be less suited. Some content is likely easily observed via video (e.g., classroom management, communication patterns), while other content may be inferred (e.g., internal self-regulation processes), or may be quite difficult to observe in a single video excerpt (e.g., activation of prior knowledge, longitudinal development).

In empirical studies, several learning goals were identified that can be successfully addressed with video-based activities, for example, the ability to notice significant aspects of student thinking, engaging into productive conversations about classroom interactions, and the acquisition of factual knowledge or subject-related knowledge about instruction.

First, researchers found that video can help to develop pre-service and in-service teachers' ability to notice significant aspects of student thinking (Sherin & Han, 2004; Sherin & van Es, 2009; van Es & Sherin, 2002). In particular, watching and discussing video excerpts with peers in *video clubs* was found to significantly promote increased attention to substantive student thinking and to the use of sophisticated strategies for analyzing student thinking. Furthermore, van Es and Sherin (2002) found that the use of video with pre-service teachers fostered greater attention to the details of specific classroom events, rather than attention to more general features of a classroom.

Second, Borko, Jacobs, Eiteljorg, and Pittman (2008) noted that video-based professional development fostered productive conversations about both student thinking and teachers' instructional practices. They also found that video-based programs can help teachers to examine teaching and learning in ways that lead to improvements in instruction. They explain that artifacts of teaching and learning, such as video, have the potential to focus teachers' attention on relevant aspects of classroom practice (Koellner, Jacobs, Borko, Roberts, & Schneider, 2011). Borko et al. (2008) showed classroom videos to in-service teachers during profes-

sional development workshops; their analyses fostered the development of a shared language for discussing teaching and learning as well as supportive community in which to do so. These findings suggest that pre-service teachers who work with video and who are guided by experienced facilitators may also adopt a shared language and engage in productive conversations about teaching and learning.

Third, video can also significantly foster more specific skills related to content knowledge such as the acquisition of factual knowledge about instructional approaches one can use in classroom and which are, in turn, based on different theories on learning and teaching (Seidel, Blomberg, & Renkl, 2013), or specific subject-related knowledge such as chemistry teachers' understanding about the nature of science (Lin & Chen, 2002). These examples show that video can support a variety of learning goals that address content, pedagogical content, and general pedagogical knowledge about teaching and learning in classrooms. Furthermore, video significantly encourages developing a shared understanding of concepts and ideas, as well as communicative and reflective skills of teachers in observing classroom situations (Santagata, Zannoni, & Stigler, 2007; Stockero, 2008; van Es and Sherin, 2002).

Still, each teaching-learning interaction includes different (interrelated) learning goals. Therefore, one should carefully identify the intended learning goals represented in the selection of video. Video-based teaching demands an orientation towards concrete learning goals in order to direct the use of video properly. Video should not be used "just because" since that risks a lack of goals to orient the use of video. Further, it is important to reflect on the suitability of the learning goals to be fostered by a technological tool such as video.

3.2 Understanding video as a tool embedded in a design approach

In addition to specifying learning goals, it has to be decided which instructional strategies to use when embedding video into instruction in order to align the video-based activity with the chosen goals. In considering the question of how different designs support video-based pre-service teacher learning, we found that there has been relatively little systematic research in this area. There is, however, some research on the kind of scaffolding provided to pre-service teachers when they work with video examples. It turned out prompts are important in order to guide pre-service teachers' video analyses (Phillip & Cabral, 2005; Santagata & Angelici, 2010; Santagata & Guarino, 2011; van Es & Sherin, 2002). Providing a specific focus, a lens through which pre-service teachers can watch the videos, was found to alleviate some of the potential overload that novices face when watching video (Schworm & Renkl, 2007). Likewise, van Es and Sherin (2008) have described specific facilitator moves and questions that significantly and effectively guide teacher viewing including asking about particular student ideas and/or comparing across ideas raised in class. Similarly, Santagata and colleagues (2007) presented a frame-

work comprised of specific questions intended to guide teacher learning around the lesson goals, student understanding, and the teaching taking place. These questions have been compared and contrasted to another set of questions that were found not to be as effective (Santagata & Angelici, 2010).

The existing research also suggests that different instructional approaches overall matter when supporting teacher learning via video. Consider, for example, a more situated approach and a more cognitive approach. Both may recognize the value of working with authentic, real world scenarios such as video but call for using video as a resource for learning in different ways.

The idea behind learning from a situative point of view is that knowledge is grounded in the contexts and constraints of practice (Lave & Wenger, 1991; Leinhardt, 1990; Putnam & Borko, 2000), and learning is understood as a social process. Learning environments designed according to situative principles aim to connect (situate) the context of knowledge acquisition to the contexts of future knowledge application in order to enhance knowledge application. Situated learning environments are designed to immerse the learner in complex situations and thus, seem well suited for supporting novice teachers' learning with video. In line with a situative approach, video examples are presented in order to make learners with the complexity of classroom action familiar, from which they then derive *rules* (Korthagen & Kessels, 1999; Santagata et al., 2007). Using video examples as a problem anchor to elicit learners' mental action and instructional action in order to derive rules requires a degree of indirect guidance in terms of support for group thinking processes.

A complementary view on learning is the cognitive approach. One currently prominent cognitive approach is Cognitive Load Theory (Sweller, van Merriënboer, & Paas, 1998). This theory stresses that the human cognitive architecture is restricted and specifically, that the cognitive capacity in working memory is limited (Sweller et al., 1998). Therefore, if a learning task requires too much capacity, learning will be hampered. To avoid overload, supports such as scaffolding are used in an attempt to optimize the use of working memory capacity and refrain from overwhelming the learner (Kirschner, Sweller, & Clark, 2006). In particular, Schworm and Renkl (2007) showed that, when observing video, instructional aids such as prompts that direct the learners' attention help to decrease overload for pre-service teachers. These findings are in line with research on teacher expertise showing that experts and novices significantly differ in what they can see in video without instructional support (Berliner, 1986, 1991; Sabers, Cushing, & Berliner, 1991). For example, experts are able to reason about objects or classroom situations they observe, whereas novices tend to only describe what they see (Berliner, 1986). Further, experts classify instructional situations in a way that is more elaborated than novices and differentiate between more and less relevant information (Berliner, 1991). In contrast, novices typically classify events based on surface characteristics and without connections among information. When novices observe video, there is a need to focus their attention on specific elements and to highlight key connections among these elements. Thus, Cognitive Load Theory predicts that ap-

proaches which aim to reduce complex events for novice learners may be effective in supporting pre-service teachers' learning. Video can be overwhelming, particularly for novice viewers (Erickson, 2007) and when first exposed to (videotaped) classroom situations, novices tend to rather focus on irrelevant features (Fuller & Manning, 1973). Hence, using the principles of Cognitive Load Theory when embedding video into a learning environment might facilitate pre-service teacher learning. Furthermore, with a cognitive approach, video examples tend to be used in order to illustrate *rules* and set them in the context of schools and classrooms. Doing so requires direct guidance and that the content to be illustrated is taught in advance.

Studies conducted by Blomberg and colleagues (Blomberg, Sherin, Renkl, Glogger, & Seidel, in press; Seidel et al., 2013) explored the relationship between cognitive and situative instructional approaches in two video-based programs designed to foster pre-service teachers' ability to reflect on instruction over the course of a three-month term. They found that the cognitive approach, which offered more direct guidance initially, significantly facilitated expert-like reflections (integrating observations with knowledge about teaching and learning). However, this effect was not stable over time. Interestingly, over time, the group which experienced video embedded according to a situative approach was able to maintain a focus on engaging consistently in expert-like categories. Indirect guidance and social learning as offered in this learning environment thus seemed to foster the ability to reflect about learning in the longer run. However, situative approaches risk a dominance of description and "premature evaluations" when first confronting the learners with video. These findings indicate that when fostering the ability to reflect on classroom events, video-based learning environments designed according to principles of situated learning might better be suited for fostering reflection in the long run, and cognitive approaches might better be suited when expert-like reflections are demanded within a short period of time. In addition, it was shown that video embedded according to the cognitive strategy significantly allowed better acquisition and application of factual knowledge and schemas about theories on learning and teaching (Seidel et al., 2013).

The reviewed approaches to video based learning and corresponding research findings illustrated that the employed instructional approach or activity (e.g., prompts) moderates the video's contribution to pre-service teacher learning. Instructional strategies and activities have distinct impacts on the kinds of reflection patterns. These findings suggest that the learning goal and purpose at hand should determine which instructional strategy is employed. In a nutshell, it seems to be beneficial to choose a particular instructional strategy or activity when embedding video in order to promote the desired learning outcomes.

3.3 Choose appropriate video material

Having specified the learning goals and design approach underlying one's use of video, there remain additional issues to consider when utilizing video for teacher learning. In particular, one must choose appropriate videos to use. Given the state of art, we argue that the kind of video material that is selected seems to play a central role in the learning, and we highlight three dimensions to consider. The goals one has selected will, of course, fundamentally influence this decision as will the nature of the instructional approach one plans to use to guide the pre-service teachers' viewing and analysis.

3.3.1 Own video material or external video material?

One issue to consider is whether the videos show the learners' own instruction – if they have had practical experience – or the teaching of others. Seidel et al. (2011) used an experimental approach to investigate the effect that analyzing own vs. external video had on in-service teachers' (1) experience of video analysis as a meaningful learning tool, (2) noticing relevant components of teaching and learning, and (3) articulation of critical incidents. The clips showed science classrooms that were homogenous in terms of methods and approaches that are used. Teachers who analyzed their own teaching perceived the learning tool significantly as more meaningful than did teachers who analyzed another teacher's teaching. Specifically, these teachers tended to notice more significant events in terms of relevant components of teaching and learning compared to teachers analyzing other lessons. However, they significantly articulated fewer critical incidents than did those who analyzed another teacher's instruction. These findings lead to the conclusion that material with higher personal relevance may more effectively stimulate substantive reflection on teaching and learning but that videos of others' teaching might be more useful for developing a critical stance toward instruction. Accordingly, the potential value of using both kinds of video material depends on one's learning goals. Research revealed how important it is in teacher education to use video of pre-service teachers' instruction as soon as it is available to ensure broad teacher learning. In related work, Abell, Bryan, and Andersen (1998) argued that watching someone else teach in a video does not necessarily ensure that pre-service teachers will reflect on their own beliefs and practices because the video cases may feel too distant. Furthermore, watching one's own video also allows pre-service teachers and their educators to evaluate teaching. Likewise, in Performance Assessment for California Teachers (PACT), pre-service teachers' videotaped teaching is analyzed according to specific teaching standards and used as a measure to evaluate their teaching. In this regard, watching and analyzing their own video may help pre-service teachers prepare for evaluations such as the PACT. One component of the PACT portfolio is a video of one's own teaching, with reflective comments.

3.3.2 Familiar or unfamiliar instruction?

A second dimension to consider is whether pre-service teachers view familiar instruction or clips that show unknown instructional methods or subjects. Again, the choice of material on this dimension fundamentally depends on the learning goals at hand. For example, Brophy (2004) explained, “ideal videos show teachers with whom viewers can identify implementing a curriculum similar to the one they use or will use, in a classroom similar in appearance and student composition to the classroom in which they teach or will teach” (p. 289). Research on model-based learning confirmed Brophy’s idea by identifying the similarity of the model and its observer as one of the core moderators for the success of model-based learning (Bandura, 1986; Schunk, 1987, 1999). These findings suggest that using video material that shows familiar teaching might be well suited for illustrating specific teaching techniques that you intend the pre-service teachers to adopt. In contrast, unfamiliar video material might include rarely observed classroom interactions such as reform-oriented teaching that pre-service teachers would also benefit from seeing. To be clear, observing unfamiliar classroom instruction via video may require skilled scaffolding in order to accurately interpret the teachers’ intentions and actions (Renkl, Hilbert, & Schworm, 2009). In sum, familiar and unfamiliar video material appeared likely to fulfill different purposes in pre-service teachers’ learning.

3.3.3 Best-practice or typical practice?

Another decision to make in selecting video concerns whether pre-service teachers are best served by working with video that illustrates exemplary teaching practices or video that shows more typical instructional practices. Research on teacher learning emphasizes the importance of authentic learning contexts, but does not specify the nature of the authentic practice. Some teacher education programs promote the use of video as a method for highlighting “best practices” within a particular subject area to broaden pre-service teachers’ awareness of the variety of possible approaches to teaching and learning (Oonk, Goffree, & Verloop, 2004; Rosaen, Degan, VanStratt, & Zietlow, 2004). In line with that, Bliss and Reynolds (2004) used videos of National Board Certified teachers to help pre-service teachers create visions of themselves as teachers in the world of quality teaching. Other researchers, on the contrary, suggest that it is more effective to have teachers investigate video that demonstrates more typical practices (Sherin, 2004b). The idea here is that pre-service teachers are more likely to reflect substantively on practices that they view as possible images from their own classrooms. Linking these different options to research on model-based learning, which has systematically compared different types of models, findings indicate that the most effective models are not those that represent particularly good performers but rather ones in which performers initially show difficulties and model how to overcome these difficulties

(i.e., coping models instead of mastery models) (Kitsantas, Zimmerman, & Cleary, 2000; Schunk, 1987). In the same vein, Santaga and Guarino (2011) argue that the use of video showing other novice teachers might help pre-service teachers identify with the teacher in the video and therefore assist in assuring that the practices portrayed are within their zone of proximal development (Vygotsky, 1978; Chaiklin, 2003).

In sum, both kinds of video material – best-practice and typical practice – seem to have potential for fostering learning and for attaining certain learning goals. The match between current own practices and possible images of future practices seems to be of particular relevance. In this sense, a zone of proximal development has to be identified in video-based teacher learning.

In a nutshell, several features of video may be considered when selecting video material for use with pre-service teachers. When deciding what video material to use, one's choice should again depend on the learning goal at hand. Furthermore, the research presented has suggested that own, familiar, and typical-practice video was more suitable to actively engaging the learners with video material with which they can identify and that feels motivating. External, unfamiliar, and best-practice video material was more suitable when seeking to distance the viewer from the practice in order to foster a critical stance and to convey new skills.

3.4 Be aware of videos' limitations

As outlined above, there are many potential benefits of using video to foster pre-service teacher learning. Nevertheless, video also has limitations that should be kept in mind (Goldman et al., 2007; Sherin, 2004a). When deciding whether or not to use video, one should weigh such weaknesses against the perceived strengths of video as a technological tool for teacher education. Furthermore, it is important to consider ways to address these limitations.

One limitation of video is that it shows an image from reality that is based on a particular focus and the angle of the camera (Krammer et al., 2006). Furthermore, the information that is captured may be much more limited as compared to in-vivo classroom observation (Sherin, 2004a). Thus, while video is often presumed to illustrate an objective view of a classroom, that is not always the case. Furthermore, video is seen through the filter of the viewer's cultural background, educational philosophy, and his construal of the task of watching video (Miller & Zhou, 2007). Thus viewers may inadvertently bring their own biases to bear when watching and interpreting events shown on video. Finally, much video material that is available is minimally edited footage (video that is almost completely unedited, without cuts, montage, or other viewer supporting techniques) and therefore, even a short clip can overload novice viewers (Erickson, 2007). Research on animation suggested that segmenting the video into smaller units and giving the learners control of the pace of presentation may prevent such overload and foster learning (e.g., Wouters, Tabbes, & Paas, 2007).

Miller and Zhou (2007) emphasized that these challenges in the use of video call for careful consideration of how instruction with video is designed and used to support (pre-service) teacher learning. In order to cope with the limitations of video as a tool, we recommend being aware of those limitations and carefully planning activities to explicitly address them. The fact that video provides a certain slice of reality and that the information presented might be somehow limited, can be compensated by, for example, offering contextual background information. In addition, the tendency of pre-service teachers to be overwhelmed by video, and/or to view video with a particular filter can be compensated by guiding their attention and structuring the viewing process. Furthermore, keeping in mind the many benefits of video as compared to other methods such as written case studies may help to guide the design of productive learning activities.

3.5 Align the assessment of learning to the way you teach

Effectively integrating video into pre-service teacher education will likely yield a certain level of innovation in existing teacher education programs. However, innovative ways of teaching demand innovative ways of measuring learning outcomes. That is, new forms of instruction call for new ways to measure learning outcomes – in this case, methods that align with the goals of video-based learning.

According to Biggs and Tang (2007), such a “constructive alignment” of teaching and measuring outcomes will fundamentally increase teaching quality at the university. Therefore, using video in combination with certain tasks (e.g., reflection tasks) as an evaluation instrument offers a promising approach for aligning instruction and assessment. In fact, it has become more common for pre-service teachers to use video to meet the requirements for receiving teaching certification (such as PACT in California; Pecheone & Chung, 2006). Similarly, National Board certification requires the inclusion of video excerpts of one’s teaching as well as reflections on the video. These developments indicate that the task of noticing and reasoning about video-taped instruction has been becoming accepted as an element of teaching expertise (Kersting, Givvin, Sotelo, & Stigler, 2010; Santagata, Gallimore, & Stigler, 2005).

There are additional novel attempts to assess pre-service teacher learning outcomes in using video-based techniques. For instance, Seidel, Schwindt, Stürmer, and Blomberg (2008) developed the computer-based online tool Observer to measure pre-service teachers’ professional vision. Professional vision has been identified as an important element of teacher expertise that can be developed in pre-service teacher education (Goodwin, 1994; Sherin, 2002). Professional vision describes teachers’ ability to apply their knowledge of teaching and learning to notice and interpret significant features of classroom situations (van Es & Sherin, 2008). In the Observer, participants were faced with classroom video clips and were asked to evaluate aspects of the instruction by means of rating items. The items focused on three teaching and learning components (Seidel & Shavelson, 2007): goal clari-

fication, scaffolding, and learning climate. *Goal clarity* reflected whether the teacher explicitly clarified short-term and long-term objectives (e.g., lesson goals and learning objectives) and tasks by, for example, providing advance organizers to structure the process of instruction. Features of *scaffolding* included meaningful constructive feedback and posing challenging and open-ended tasks and questions. A *positive learning climate* is one in which, for example, student contributions are valued and students experience respect and compassion. The tool can be used to evaluate interventions as well as to diagnose (pre-service) teachers' professional vision.

Studiocode® is another example of software that can be used to create video-based assessments of pre-service teacher learning outcomes. Studiocode's functions allow participants to mark critical events in the video and add detailed annotation related to particular video segments (for a more detailed discussion of using Studiocode for analysis, see McDonald & Kelly, 2007). McDonald (2010) used Studiocode to both foster and assess pre-service teachers' reflective skills as one component of an evaluation of video-based university courses.

Santagata and Guarino (2011) also used a video-based approach to assess pre-service teachers' learning. The "Lesson Analysis Framework" (Santagata, Zannoni, & Stigler, 2007) provides questions (prompts) that can be used to scaffold teacher analyses of classroom lessons. The lesson analysis framework begins by showing the pre-service teachers clips of teachers interviewing individual students. The goal is to raise the pre-service teachers' appreciation of the complexity of students' mathematical thinking. These clips are followed by a sequence of clips from mathematics lessons in one classroom to provide (effective) examples from practice. At the end of the framework, the pre-service teachers are asked to select video clips that show student thinking and to present a rationale for their choice. Learning progress is measured before and after doing the framework by analyzing pre-service teachers' reflections and discussions over the course of the Lesson Analysis Framework and their behavior with respect to choosing clips and reasoning about their choice.

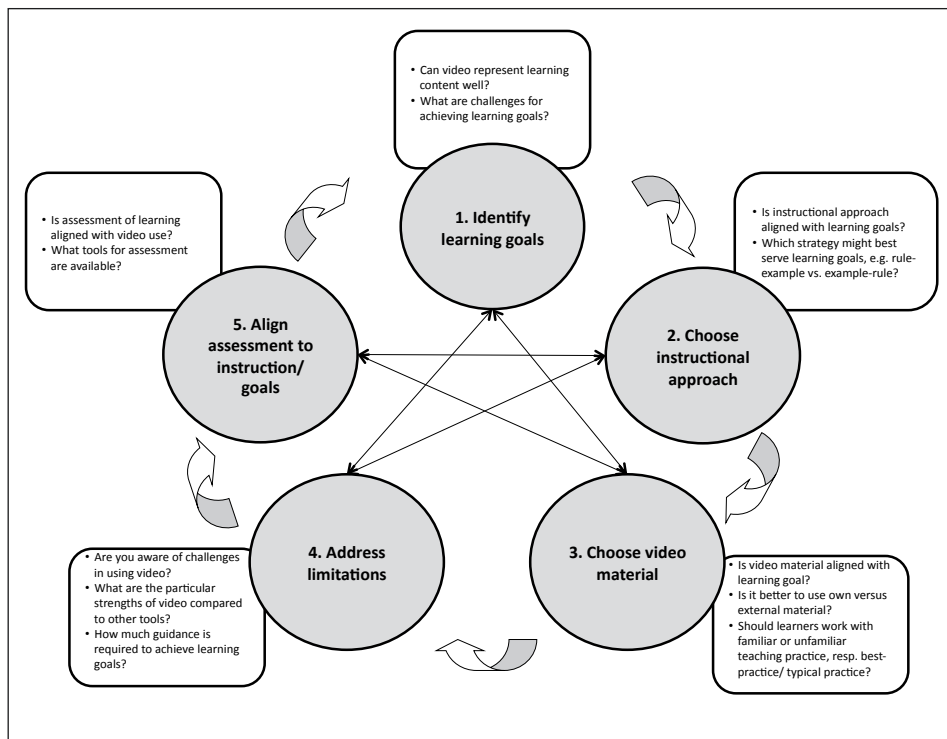
Finally, Kersting (2008) used video clips of mathematics classroom instruction as item prompts to measure teachers' knowledge of teaching mathematics when they were analyzing the video prompts in open format questions. This approach implements a video-based measure of teacher knowledge of mathematics teaching with various dimensions that are likely to be aligned with many video-based teacher learning experiences. Also, Kersting et al. (2010) showed that this measure of teachers' mathematics knowledge significantly predicted the success of these teachers' students in mathematics achievement.

Aligning video-based instruction with its assessment is important for two reasons: First, learners' motivation to work with video can be heightened when they understand that their learning will be assessed by video as well. Second, the use of video for evaluation may help to provide more authentic and reliable outcome measures that are aligned with the learning goals of the program or course, and with the use of video to support the learning process.

4. Summary

As a summary, the visual representation of the five heuristics depicted in Figure 1 was expanded by including questions that can guide specification for using video in pre-service teacher education (Figure 2). This extension highlights the point that effective use of video in pre-service teacher education requires many decisions, in order to ensure that educational experiences and assessments are aligned with learning goals. In addition, it is stressed that these decisions will require weighing the affordances and constraints of different approaches and balancing different priorities for pre-service teacher learning. Also, links between all the different decision steps are included, indicating that in practice the steps might be interrelated, cyclical, and in varying order.

Figure 2: Specification and illustration of research-based heuristics



5. Conclusions

Teaching is arguably one of the most important professions that exist, since it is directly linked to student learning and with that to their educational achievement (Hanushek & Rivkin, 2010). However, the preparation of prospective teachers is not as grounded in practice as the preparation for many other fields with high re-

sponsibilities (pilots, physicians, etc.). As a result, many beginning teachers struggle when starting to teach. These struggles then reinforce the collective, deep-seated belief that good teaching is either innate or learned through hard knocks – a belief that serves a damaging obstacle for teacher educators and policy makers working to design effective teacher education programs (Ball & Forzani, 2010).

To better prepare pre-service teachers to meet their professional demands, we need detailed knowledge about how to design effective learning settings that ground learning in practice (Grossman & McDonald, 2008). And clearly, the kinds of practice matter. Ideally, it should represent the complexity of classroom interactions while not being overwhelming. In particular, pre-service teachers seem to need well-dosed practice in order to understand the complexity of classrooms and be able to integrate their knowledge about teaching. Doing so demands a shift in the focus in teacher education from knowledge (what teachers know) to practice (what teachers do) (Ball & Forzani, 2009).

In this paper, we suggested that classroom video can be a powerful technological tool for focusing pre-service teacher education on practice. Research showed that video successfully bridges the learning at university and the knowledge application in school and can therefore guide pre-service teachers' classroom actions. But video only effectively grounds learning in practice when carefully selected and embedded in learning environments.

In this manuscript, the growing body of empirical evidence on using video as tool to facilitate practice is reviewed. The synthesis was organized around a set of heuristics. From the perspective of technology in education, teacher educators should be encouraged to use video in their teaching. In addition, it seems important that video “users” are provided with research-based knowledge on key issues involved in decisions about video use. The heuristics in this manuscript serve as rules of thumb since each specific teacher learning system demands a specific adaption. Despite this need to have autonomy in deciding how to use video, it is nevertheless argued that certain rules of thumb follow from the research presented here.

Despite the research body presented in this paper, it has to be noted that there is still a lack of well-founded knowledge about how to properly understand and use video as a technological tool in pre-service teacher education. Therefore, writing this paper was motivated by the need to conduct additional research on the systematic use of video as a tool in teacher education. In particular, experimental or quasi-experimental studies are required that use findings achieved from qualitative studies in order to systematically test for advantages and disadvantages of using video in pre-service teacher education. In addition, it has to be studied in more detail which processes (as indicated by the interrelation of the five heuristics) are most effective in using video in the teaching-learning process. What are “naturally” occurring cycles of adapting instructional strategies to learning goals, choosing video material, and aligning assessment to the use of video? What cycles are most effective for novice pre-service teachers compared to more advanced learners? In order to answer these questions, also longitudinal studies would help to learn more

about the long-term benefits of using video in pre-service teacher education, and thus, reaching the goal of improving teacher education programs by means of practice-based elements.

Accumulating knowledge about how and why pre-service teachers learn in relation to video will advance the scientific understanding of the nature of pre-service teacher learning and, in particular, of the relationship between the tool video and their learning.

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References

- Abell, S. K., Bryan, L. A., & Andersen, M. A. (1998). Investigating preservice elementary science teacher reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Education*, *82*, 491–510. doi:10.1002/(SICI)1098-237X(199807)82:4<491::AID-SCE5>3.0.CO;2-6
- Abell, S. K., & Cennamo, K. S. (2004). Videocases in elementary science teacher preparation. In J. Brophy (Ed.), *Using video in teacher education* (pp. 103–130). Oxford, UK: Elsevier.
- Anderson, G., Frager, A., & Boling, C. (1982). Developing instructional competence in field-based programs: Videotape protocols versus role-play simulations. *Teacher Educator*, *18* (3), 16–25.
- Areglado, N. (1999). I became convinced. *Journal of Staff Development*, *20* (1), 35–37.
- Ball, D. L. (2000). Bridging practices: Intertwining content and pedagogy in teaching and learning to teach. *Journal of Teacher Education*, *51*, 241–247.
- Ball, D. L., & Forzani, F. M. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education*, *60* (5), 497–511. doi: 10.1177/0022487109348479
- Ball, D. L., & Forzani, F. M. (2010). What does it take to make a teacher? *Phi Delta Kappan*, *92* (2), 8–12.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.
- Barker, S. P. (1988). Comparison of effectiveness of interactive videodisc versus lecture-demonstration instruction. *Physical Therapy*, *68* (5), 699–703.
- Berliner, D. C. (1986). In pursuit of the expert pedagogue. *Educational Researcher*, *15* (7), 5–13. doi: 10.3102/0013189X015007007
- Berliner, D. C. (1991). Perceptions of student behavior as a function of expertise. *Journal of Classroom Interaction*, *26* (1), 1–8.
- Biggs, J. B., & Tang, C. (2007). *Teaching for quality learning at university* (3rd ed.). Maidenhead, UK: Open University Press/McGraw Hill.
- Bliss, T., & Reynolds, A. (2004). Quality visions and focused imagination. In J. Brophy (Ed.), *Using video in teacher education* (pp. 29–52). Oxford, UK: Elsevier.

- Blomberg, G., Sherin, M. G., Renkl, A., Glogger, I., & Seidel, T. (in press). Understanding video as a tool for teacher education: Investigating instructional strategies integrating video to promote reflection. *Instructional Science*, *accepted after revision*.
- Borko, H., Jacobs, J., Eiteljorg, E., & Pittman, M. E. (2008). Video as a tool for fostering productive discussions in mathematics professional development. *Teaching and Teacher Education*, *24* (2), 417–436.
- Brophy, J. (Ed.). (2004). *Using video in teacher education*. Amsterdam, Netherlands: Elsevier.
- Carlson, H. L., & Falk, D. R. (1990). Effectiveness of interactive videodisc instructional programs in elementary teacher education. The entity from which ERIC acquires the content, including journal, organization, and conference names, or by means of online submission from the author. *Journal of Educational Technology Systems*, *19* (2), 151–63.
- Chaiklin, S. (2003). The zone of proximal development in Vygotsky's analysis of learning and instruction. In A. Kozulin, B. Gindis, V. Ageyev, & S. Miller (Eds.), *Vygotsky's educational theory and practice in cultural context* (pp. 39–64). Cambridge, UK: Cambridge University Press.
- Clarke, D. J., Mesiti, C., O'Keefe, C., Xu, L. H., Jablonka, E., & Mok, I. A. C. (2008). Addressing the challenge of legitimate international comparisons of classroom practice. *International Journal of Educational Research*, *46* (5), 280–293. doi:10.1016/j.ijer.2007.10.009
- Cochran-Smith, M. (2003). Assessing assessment in teacher education. *Journal of Teacher Education*, *54* (3), 187–191.
- Cochran-Smith, M., & Zeichner, K. M. (2005). *Studying teacher education: The report of the AERA Panel on Research and Teacher Education*. Mahwah, NJ: LEA.
- Darling-Hammond, L., & Bransford, J. D. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco, CA: Jossey-Bass.
- Erickson, F. (2007). Ways of seeing video: Toward a phenomenology of viewing minimally edited footage. In R. Goldman, R. Pea, B. Barron & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 145–155). Mahwah, NJ: Lawrence Erlbaum.
- Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record*, *103* (6), 1013–1055.
- Ferdig, R. E., Roehler, L., & Pearson, P. D. (2001). Scaffolding preservice teacher learning through web-based discussion forums: An examination of online conversations in the Reading Classroom Explorer. *Journal of Computing in Teacher Education*, *18* (3), 87–94.
- Fukink, R. G., Trienekens, N., & Kramer, L. C. (2011). Video feedback in education and training: Putting learning in the picture. *Educational Psychology Review*, *23*, 45–63. doi: 10.1007/s10684-010-9144-5
- Fuller, F. F., & Manning, B. A. (1973). Self-confrontation reviewed: A conceptualization for video playback in teacher education. *Review of Educational Research*, *43* (4), 469. doi:10.2307/1170077
- Goldman, R., Pea, R., Barron, B., & Derry, S. J. (Eds.). (2007). *Video research in the learning sciences*. Mahwah, NJ: Lawrence Erlbaum.
- Goodwin, C. (1994). Professional vision. *American Anthropologist*, *96*, 606–633. doi:10.1525/aa.1994.96.3.02a00100
- Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record*, *111* (9), 2055–2100.
- Grossman, P., & McDonald, M. (2008). Education back to the future: Directions for research in teaching and teacher education. *American Educational Research Journal*, *45* (1), 184–205. doi: 10.3102/0002831207312906

- Grossman, P. L. (2005). Research on pedagogical approaches in teacher education. In M. Cochran-Smith, & K. Zeichner (Eds.), *Review of research in teacher education*. Washington, DC: American Educational Research Association.
- Hanushek, E. A., & Rivkin, S. G. (2010). The quality and distribution of teachers under the no child left behind act. *The Journal of Economic Perspectives*, 24 (3), 133–150. doi: <http://dx.doi.org/10.1257/jep.24.3.133>
- Hiebert, J., Gallimore, R., & Stigler, J. W. (2002). A knowledge base for the teaching profession: What would it look like and how can we get one? *Educational Researcher*, 31 (5), 3–15. doi:10.3102/0013189X031005003
- Kersting, N. (2008). Using video clips of mathematics classroom instruction as item prompts to measure teachers' knowledge of teaching mathematics. *Educational and Psychological Measurement*, 68 (5), 845–861. doi:10.1177/0013164407313369
- Kersting, N. B., Givvin, K. B., Sotelo, F. L., & Stigler, J. W. (2010). Teachers' analyses of classroom video predict student learning of mathematics: Further explorations of a novel measure of teacher knowledge. *Journal of Teacher Education*, 61 (1–2), 172–181. doi: 10.1177/0022487109347875
- Kinzer, C. K., & Risko, V. J. (1998). Multimedia and enhanced learning: Transforming preservice education. In D. Reinking, M. C. McKenna, L. D. Labbo, & R. D. Kieffer (Eds.), *Handbook of literacy and technology: Transformations in a post-typographic world*. New York, NY: Routledge.
- Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, 41 (2), 75–86. doi: 10.1207/s15326985ep4102_1
- Kitsantas, A., Zimmerman, B. J., & Cleary, T. (2000). The role of observation and emulation in the development of athletic self-regulation. *Journal of Educational Psychology*, 92, 811–817. doi:10.1037/0022-0663.92.4.811.
- Koellner, K., Jacobs, J., Borko, H., Roberts, S., & Schneider, C. (2011). Professional development to support students' algebraic reasoning: An example from the Problem-Solving Cycle Model. In J. Cai, & E. Knuth (Eds.), *Early algebraization: A global dialogue from multiple perspectives* (pp. 429–452). New York, NY: Springer.
- Korthagen, F. A. J., & Kessels, J. P. A. M. (1999). Linking theory and practice: Changing the pedagogy of teacher education. *Educational Researcher*, 28 (4), 4–17. doi:10.3102/0013189X028004004
- Krammer, K., Ratzka, N., Klieme, E., Lipowsky, F., Pauli, C., & Reusser, K. (2006). Learning with classroom videos: Conception and first results of an online teacher-training program. *Zeitschrift für Didaktik der Mathematik*, 38 (5), 422–432. doi: 10.1007/BF02652803
- Lampert, M., & Ball, D. L. (1998). *Teaching, multimedia, and mathematics: Investigations of real practice*. New York, NY: Teachers College Press.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.
- Le Fevre, D. M. (2004). Designing for teacher learning: Video-based curriculum design. In J. Brophy (Ed.), *Using video in teacher education* (pp. 235–258). Amsterdam, Netherlands: Elsevier.
- Leinhardt, G. (1990). Capturing craft knowledge in teaching. *Educational Researcher*, 19 (2), 18–25.
- Lin, H. S., & Chen, C. C. (2002). Promoting preservice chemistry teachers' understanding about the nature of science through history. *Journal of Research in Science Teaching*, 39 (9), 773–792. doi:10.1002/tea.10045
- Llinares, S., & Valls, J. (2009). The building of pre-service primary teachers' knowledge of mathematics teaching: Interaction and online video case studies. *Instructional Science*, 37 (3), 247–271. doi: 10.1007/s11251-007-9043-4

- Marsh, B., Mitchell, N., & Adamczyk, P. (2010). Interactive video technology: Enhancing professional learning in initial teacher education. *Computers & Education, 54*, 742–748. doi: 10.1016/j.compedu.2009.09.011
- Masingila, J. O., & Doerr, H. M. (2002). Understanding pre-service teachers' emerging practices through their analyses of a multimedia case study of practice *Journal of Mathematics Teacher Education, 5*, 235–263. doi: 10.1023/A:1019847825912
- McDonald, S. P. (2010). Building a conversation: Preservice teachers' use of video as data for making evidence-based arguments about practice. *Educational Technology, 50* (1), 28–31.
- McDonald, S. P., & Kelly, G. J. (2007). Understanding the construction of a science storyline in a chemistry classroom. *Pedagogies, 2* (3), 1–12.
- Miller, K., & Zhou, X. (2007). Learning from classroom video: What makes it compelling and what makes it hard. In R. Goldmann, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 321–334). Mahwah, NJ: Lawrence Erlbaum.
- Oonk, W., Goffree, F., & Verloop, N. (2004). For the enrichment of practical knowledge: Good practice and useful theory for future primary teachers. In J. Brophy (Ed.), *Using video in teacher education* (pp. 131–167). San Diego, CA: Elsevier.
- Overbaugh, R. C. (1995) The efficacy of interactive video for teaching basic classroom management skills to pre-service teachers. *Computers in Human Behavior, 11* (3–4), 511–527. doi: 10.1016/0747-5632(95)80014-Y.
- Pecheone, R., & Chung, R. (2006). Evidence in teacher education: The Performance Assessment for California Teachers (PACT). *Journal of Teacher Education, 57*, 22–36. doi: 10.1177/0022487105284045
- Philipp, R., & Cabral, C. P. (2005). *Integrating mathematics and pedagogy to illustrate children's reasoning*. Upper Saddle River, NJ: Merrill Prentice Hall.
- Putnam, R. T., & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning? *Educational Researcher, 29* (1), 4–15. doi: 10.2307/1176586.
- Renkl, A., Hilbert, T., & Schworm, S. (2009). Example-based learning in heuristic domains: A cognitive load theory account. *Educational Psychology Review, 21*, 67–78. doi: 10.1007/s10648-008-9093-4
- Rich, P. J., & Hannafin, M. (2009). Video annotation tools: Technologies to scaffold, structure, and transform teacher reflection. *Journal of Teacher Education, 60* (1), 52–67. doi: 10.1177/0022487108328486
- Rosaen, C. L., Degnan, D., VanStratt, T., & Zietlow, K. (2004). Designing a virtual K-2 classroom literacy tour: Learning together as teachers explore “best practice”. In J. Brophy (Ed.), *Using video in teacher education* (pp. 169–199). San Diego, CA: Elsevier.
- Rosaen, C. L., Lundeberg, M., Cooper, M., Fritzen, A., & Marjorie, T. (2008). Noticing noticing: How does investigation of video records change how teachers reflect on their experiences? *Journal of Teacher Education, 59* (4), 347–360. doi: 10.1177/0022487108322128
- Roth, W.-M. (2007). Epistemic mediation: Video data as filters for the objectification of teaching by teachers. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences*. Mahwah, NJ: Lawrence Erlbaum.
- Sabers, D. S., Cushing, K. S., & Berliner, D. C. (1991). Difference among teachers in a task characterized by simultaneity, multidimensionality, and immediacy. *American Educational Research Journal, 28* (1), 63–88.
- Santagata, R., & Angelici, G. (2010). Studying the impact of the lesson analysis framework on preservice teachers' abilities to reflect on videos of classroom teaching. *Journal of Teacher Education, 61* (4), 339–349. doi:10.1177/0022487110369555
- Santagata, R., Gallimore, R., & Stigler, J. W. (2005). The use of videos for teacher education and professional development: Past experiences and future directions. In

- C. Vrasidas, & G. V. Glass (Eds.), *Current perspectives on applied information technologies: Preparing teachers to teach with technology* (Vol. 2, pp. 151–167). Greenwich, CT: Information Age Publishing.
- Santagata, R., & Guarino, J. (2011). Using video to teach future teachers to learn from teaching. *ZDM the International Journal of Mathematics Education*, 43 (1), 133–145. doi: 10.1007/s11858-010-0292-3
- Santagata, R., Zannoni, C., & Stigler, J. (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 (2), 123–140. doi:10.1007/s10857-007-9029-9
- Schrader, P. G., Leu, D. J., Kinzer, C. K., Ataya, R., Teale, W. H., & Labbo, L. D. (2003). Using internet delivered video cases, to support pre-service teachers' understanding of effective early literacy instruction: An exploratory study. *Instructional Science*, 31, 317–340. doi: 10.1023/A:1024690111227
- Schunk, D. H. (1987). Peer models and children's behavioral change. *Review of Educational Research*, 57, 149–174.
- Schunk, D. H. (1999). Social-self interaction and achievement behavior. *Educational Psychologist*, 34, 219–227. doi:10.1207/s15326985ep3404_3.
- Schworm, S., & Renkl, A. (2007). Learning argumentation skills through the use of prompts for self-explaining examples. *Journal of Educational Psychology*, 99 (2), 285–296. doi: 10.1037/0022-0663.99.2.285.
- Seago, N. (2004). Using video as an object of inquiry mathematics teaching and learning. In J. Brophy (Ed.), *Using video in teacher education: Advances in research on teaching* (Vol. 10, pp. 259–285). Amsterdam, Netherlands: Elsevier.
- Seidel, T., Blomberg, G., & Renkl, A. (2013). Instructional strategies for using video in teacher education. *Teaching and Teacher Education*, 34, 56–65. doi: http://dx.doi.org/10.1016/j.tate.2013.03.004.
- Seidel, T., Schwindt, K., Stürmer, K., & Blomberg, G. (2008). *Observer: Videobasiertes Tool zur Diagnose pädagogisch-psychologischer Kompetenzen bei Lehrpersonen* [Observer: video-based tool to diagnose teachers' professional vision]. Jena, Germany: Friedrich-Schiller-Universität.
- Seidel, T., & Shavelson, R. J. (2007). Teaching effectiveness research in the past decade: The role of theory and research design in disentangling meta-analysis results. *Review of Educational Research*, 77 (4), 454–499. doi: 10.3102/0034654307310317.
- Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? *Teaching And Teacher Education*, 27 (2), 259–267. doi: 10.1016/j.tate.2010.08.009.
- Sharpe, L., Hu, C., Crawford, L., Gopinathan, S., Khine, M. S., & Moo, S. N. (2003). Enhancing multipoint desktop video conferencing (MDVC) with lesson video clips: Recent developments in pre-service teaching practice in Singapore. *Teaching and Teacher Education*, 19 (5), 529–541.
- Sherin, M. G. (2002). When teaching becomes learning. *Cognition and Instruction*, 20 (2), 119–150. doi:10.1207/S1532690XCI2002_1
- Sherin, M. G. (2004a). New perspectives on the role of video in teacher education. In J. Brophy (Ed.), *Using video in teacher education* (pp. 1–28). Amsterdam, Netherlands: Elsevier.
- Sherin, M. G. (2004b). Video volunteers. *ENC Focus Review*, 11 (3), 4–6.
- Sherin, M. G., & Han, S. Y. (2004). Teacher learning in the context of a video club. *Teaching and Teacher Education*, 20, 163–183. doi: 10.1016/j.tate.2003.08.001.
- Sherin, M. G., & van Es, E. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, 60, 20–37. doi: 10.1177/0022487108328155

- Spiro, R. J., Collins, B. P., & Ramchandran, A. (2007). Reflections on a Post-Gutenberg epistemology of video use in ill-structured domains: Fostering complex learning and cognitive flexibility. In R. Goldman, R. Pea, B. Barron, & S. J. Derry (Eds.), *Video research in the learning sciences* (pp. 93–100). Mahwah, NJ: Lawrence Erlbaum.
- Stocker, S. L. (2008). Using a video-based curriculum to develop a reflective stance in prospective mathematics teachers. *Journal of Mathematics Teacher Education*, *11*, 373–394. doi: 10.1007/s10857-008-9079-7
- Stokking, K., Leenders, F., de Jong, J., & van Tartwijk, J. (2003). From student to teacher: Reducing practice shock and early dropout in the teaching profession. *European Journal of Teacher Education*, *26*, 329–350. doi:10.1080/0261976032000128175
- Sweller, J., van Merriënboer, J., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, *10* (3), 251–296. doi:10.1023/A:1022193728205
- van Es, E. (2009). Participants' roles in the context of a video club. *Journal of the Learning Sciences*, *18* (1), 100–137. doi: 10.1080/10508400802581668.
- van Es, E., & Sherin, M. G. (2002). Learning to notice: Scaffolding new teachers' interpretations of classroom interactions. *Journal of Technology and Teacher Education*, *10* (4), 571–596.
- van Es, E., & Sherin, M. G. (2008). Mathematics teachers' "learning to notice" in the context of a video club. *Teaching and Teacher Education*, *24* (2), 244–276. doi: 10.1016/j.tate.2006.11.005
- Vygotsky, L. S. (1978). *Mind and society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Whitehead, A. N. (1929). *The aims of education and other essays*. New York, NY: The Free Press.
- Winitzky, N., & Arends, R. (1991). Translating research into practice: The effects of various forms of training and clinical experience on preservice students' knowledge, skill, and reflectiveness. *Journal of Teacher Education*, *42* (1), 52–65. doi:10.1177/002248719104200108
- Wong, S. L., Yung, B. H. W., Cheng, M. W., Lam, K. L., & Hodson, D. (2006). Setting the stage for developing pre-service teachers' conceptions of good science teaching: The role of classroom videos. *International Journal of Science Education*, *28* (1), 1–24. doi: 10.1080/09500690500239805
- Wouters, P., Tabbers, H. K., & Paas, F. (2007). Interactivity in video-based models. *Educational Psychology Review*, *19*, 327–342. doi 10.1007/s10648-007-9045-4

Appendix

Table 1: Overview of studies investigating the use of video in pre-service teacher education

Authors	Year	Type of publication	Study design	Used to derive heuristics	Used to illustrate heuristics
Abell et al.	1998	Study	Qualitative		3
Abell & Cennamo	2004	Study	Qualitative	2	
Anderson et al.	1982	Study	Qualitative	3	
Areglado	1999	Study	Qualitative	1, 3	
Barker	1988	Study	Quantitative	4	
Berliner	1986	Study	Qualitative		2
Berliner	1991	Study	Qualitative		2
Bliss & Reynolds	2004	Study	Qualitative		3
Blomberg et al.	2013	Study	Quantitative		2
Borko et al.	2008	Study	Qualitative		1
Brophy	2004	Review	Qualitative	1–5	3
Carlson & Falk	1990	Study	Quantitative	2, 4, 5	
Clarke et al.	2008	Review	Qualitative	1	
Erickson	2007	Review	Qualitative		4
Ferdig et al.	2001	Study	Qualitative	1, 2, 3	
Fukkink et al.	2011	Review	Quantitative	1–5	
Fuller & Manning	1973	Review	Qualitative	2, 4	2
Kersting	2008	Study	Quantitative		5
Kersting et al.	2010	Study	Quantitative		5
Kinzer & Risko	1998	Study	Qualitative	2, 3, 5	
Kitsantas et al.	2000	Study	Quantitative		3
Koellner et al.	2011	Study	Qualitative		1
Krammer et al.	2006	Study	Qualitative	1–4	4
Lampert & Ball	1998	Study	Qualitative	1, 3	
Le Fevre	2004	Study	Qualitative	2, 3	
Lin & Chen	2002	Study	Qualitative		1
Llinares & Valls	2009	Study	Qualitative	3	
Marsh et al.	2010	Study	Qualitative	1, 2, 3	
Masingila & Doerr	2002	Study	Qualitative	3	
McDonald	2010	Study	Qualitative	3, 5	5
Miller & Zhou	2007	Study	Qualitative	3, 4	4
Oonk et al.	2004	Study	Qualitative		3
Overbaugh	1995	Study	Quantitative	2, 3, 5	
Pecheone & Chung	2006	Study	Quantitative		5
Philip & Cabral	2005	Study	Qualitative		2
Renkl et al.	2009	Study	Quantitative		3
Rich & Hannafin	2009	Review	Qualitative	1–5	
Rosaen et al.	2004	Study	Qualitative		3
Rosaen et al.	2008	Study	Qualitative	3	
Roth	2007	Study	Qualitative	1, 3	
Sabers et al.	1991	Study	Qualitative		2
Santagata et al.	2005	Review	Qualitative	1–5	5

Authors	Year	Type of publication	Study design	Used to derive heuristics	Used to illustrate heuristics
Santagata et al.	2007	Study	Qualitative	1–5	1, 2, 5
Santagata & Angelici	2010	Study	Quantitative		2
Santagata & Guarino	2011	Study	Quantitative	1, 2, 3, 5	2, 3, 5
Schrader et al.	2003	Study	Quantitative	2, 3	
Schworm & Renkl	2007	Study	Quantitative		2
Seago	2004	Study	Qualitative	2, 3	
Seidel et al.	2011	Study	Quantitative		3
Seidel et al.	2013	Study	Quantitative		1, 2
Sharpe et al.	2003	Study	Qualitative	3	
Sherin	2004a	Study	Qualitative	2, 3, 4	3, 4
Sherin	2004b	Study	Qualitative		3
Sherin & Han	2004	Study	Qualitative		1
Sherin & van Es	2009	Study	Qualitative		1
Spiro et al.	2004	Study	Qualitative	1, 2	
Stockerro	2008	Study	Qualitative	1, 2	1
Van Es	2009	Study	Qualitative	2, 3	
Van Es & Sherin	2002	Study	Qualitative	1–3	1, 2
Van Es & Sherin	2008	Study	Qualitative		2, 5
Winitzky & Arends	1991	Review	Qualitative	1–5	
Wong et al.	2006	Study	Qualitative	3	
Wouters et al.	2007	Review	Quantitative		4