Designing and Incorporating Mathematics-Based Video Cases Highlighting Virtual and Physical Tool Use

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Abstract

As there has recently been an onslaught of video cases being developed and implemented with preservice teachers, it is important to evaluate how we should use these cases. This research investigates the features elementary preservice teachers consider valuable when using video cases in mathematics education. The researchers used hierarchical cluster analysis to create a dendrogram that displayed statistically significant features. The study revealed two primary clusters—(a) cross-subject lessons emphasizing adaptations and techniques to reach a variety of learners and (b) problem-based lessons with students in groups supported by lesson analysis—as well as (c) a small third cluster of collection and distribution of materials. Ultimately, such findings can be used to guide the design and incorporation of tools for using mathematics-based video cases. (Keywords: video cases, tool-based instruction, preservice teachers, technology use)

"Video cases can give the preservice teacher a look at 'real-world' teaching situations before experiencing them firsthand. [Video cases] reduce the stress of thinking that they are being 'thrown to the lions' without any weapons."
—Preservice teacher

As this quote demonstrates, preservice teachers have some anxiety when it comes to teaching children for the first time, and different dimensions of teacher education programs influence their development, efficacy, and commitment to teaching (Daniels, Mandzuk, Perry, & Moore, 2011). Video cases can provide preservice teachers with the opportunity to observe and learn from classrooms before entering student teaching (Wong, Yung, Cheng, Lam, & Hodson, 2006). Thus, they can view common teaching situations and develop strategies to address incidents that may arise. Video cases have tremendous potential to alleviate some of the stress and anticipation experienced by developing a reflective stance (Marsh, Mitchell, & Adamczyk, 2010). However, the potential will not be actuated unless faculty make a conscious effort when developing and integrating video cases to support the preservice teachers' evolution (Kurz & Batarelo, 2010). How we develop and use video cases is a critical component of reaching this potential. In particular, we should factor in preservice teachers' preferences.

Video cases are often used to support preservice teachers' instruction in their methodology classes. Video cases allow the instructor to bring the classroom to the preservice teachers. The instructor can present a common learning situation to all of the preservice teachers, making discussions of observations more fruitful and meaningful to observers (Llinares & Valls, 2009). They can use them holistically to integrate various pedagogical or theoretical ideas and concepts in an encompassing case (Masats & Dooly, 2011). Or cases can illustrate exemplars and nonexamples, and they can be designed or utilized with a focus on specific pedagogical or theoretical components (Manouchehri & Enderson, 2003). They can also be used to model the complexity of the classroom and help preservice teachers become more aware of this complexity (Eilam & Poyas, 2006).

This research examines preservice teachers' preferences in relation to mathematics video cases that integrate tools. Tools are defined broadly to include physical manipulatives, virtual manipulatives, and other technology. Explicitly, this research answers the question: What features do elementary preservice teachers want from video cases implemented in their methodology courses emphasizing mathematics supported by the use of tools?

Video Cases

Numerous studies have outlined the benefits of using video cases in mathematics education. Alsawaie and Alghazo (2010) used video lesson-analysis methodology to measure preservice teachers' ability to notice noteworthy classroom interactions. The results indicated that when teachers used an online forum to discuss the video cases, they performed better than the control group. Furthermore, the experimental group paid closer attention to student learning and provided deeper evidence in relation to what they saw in the video case (Alsawaie & Alghazo, 2010). In another study, results were similar. When video cases were used with preservice teachers, they used more evidence to justify their observations and made more references to students' thinking (Stockero, 2008).

Teacher self-reflection is a common topic regarding research on the use of video cases in teacher development (Blomberg, Stürmer, & Seidel, 2011; Kong, 2010; Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011; Sherin & van Es, 2009). Kong (2010) evaluated the effectiveness of a web-enabled video system that permitted preservice teachers to record their classroom performance and then self-reflect on their own videos. The study results indicated that the video system significantly increased the depth of preservice teachers' reflective thoughts about their study areas and professional knowledge of teaching. The research on the impact of analyzing videos of one's own versus others' teaching on teacher learning, particularly on knowledge activation and professional vision, indicates that teachers who analyzed their own teaching experienced higher activation, whereas findings related to professional vision were inconclusive. Teachers noticed more relevant teaching and learning components but were less self-reflective (Seidel, Stürmer, Blomberg, Kobarg, & Schwindt, 2011). Furthermore, Blomberg, Stürmer, and Seidel (2011) believe that video case use can enhance the development of preservice teachers into more aware educational experts by focusing on professional vision.

Sherin and van Es (2009) explored the development of teachers' professional vision through participation in a video club where teachers watched and discussed video excerpts from each others' classrooms. The study results suggest that participating in a video club positively influences the teachers' professional vision.

Several research studies focus on the active role of preservice teachers in professional development based on use of video cases (Marsh, Mitchell, & Adamczyk, 2010; Mastas & Dooly, 2011; Zhang, Lundeberg, Koehler, & Eberhardt, 2011). When preservice teachers played the roles of both teacher and learner, they were able to co-construct teaching knowledge and develop digital competencies (Mastas & Dooly, 2011). Initial teacher education programs for science trainee teachers could be enhanced by use of interactive video technologies that enable reflective practice and facilitate collaborative learning (Marsh, Mitchell, & Adamczyk, 2010). Teachers might learn from published video, teachers' own video, and their colleagues' video, and at the same time offer recommendations for use of video in professional development (Zhang, Lundeberg, Koehler, & Eberhardt, 2011).

Recent studies (Koc, 2011; So, Pow & Hung, 2009) have focused on video case implementation in the university classroom and their influence on preservice teachers' growth. The results of the study, in which preservice teachers developed and analyzed video cases, indicated that video case implementation can improve preservice teachers' motivation, learning, empathy, and the construction of professional identity (Koc, 2011). A similar study explored ways that preservice teachers acquired teaching-related knowledge through the interactive use of a video database and an online discussion forum (So, Pow, & Hung, 2009).

Research indicates that there are multiple dimensions to understanding preservice teachers' knowledge of technology used in mathematics education (Johnston & Moyer-Packenham, 2012). Hence, teacher preparation programs should include courses demonstrating valid uses of technology for solving mathematical problems (Barton, 2009). Teacher education courses in mathematics and technology are still in the process of formation; they are relatively new. It is an opinion of modern researchers that these courses should include content related to curriculum; potentials of software; instrumental genesis; new and old tasks; new teaching abilities; professional context; and teaching strategies such as demonstration, role playing, "in practice," and learning communities (Grugeon, Lagrange, Jarvis, Alagic, Das, & Hunscheidt, 2010). Recent literature commonly focuses on the evaluation of the impact of tools or technology environments on learning mathematics (Bu, Spector, & Haciomeroglu, 2011; Freiman, Beauchamp, Blain, Lirette-Pitre, & Fournier, 2011).

The reviewed research suggests that video cases can have a positive impact on teachers' professional vision development, facilitate the active role of preservice teachers in learning, and have a general positive influence on preservice teachers' growth. Furthermore, the literature indicates that a variety of technology-rich environments have a positive influence on mathematics teaching and learning. However, based on a gap discovered in the literature, there is a need for further research on the audience's preferences that are linked to learning with video cases and with a focus on preservice teacher preferences related to the use of tools, technology, and manipulatives in mathematics instruction. Even though preservice teachers are novices, their needs should still be respected and factored into how cases are designed and incorporated. The expert would have to use his/her knowledge to support the preservice teachers' needs, as they are not knowledgeable enough (yet) to specifically state how their preferences should be addressed. The preservice teachers simply know where they feel inadequately educated. The expert should help fill this gap.

Personal Construct Theory (Kelly, 1955) attempts to understand how people make distinctions among objects. People are regarded as scientists; they make distinctions among objects (elements) using constructs. The benefit of using this theory is that it provides insight based on the individual participants' beliefs (Walker & Winter, 2007). There is less researcher bias, as the participants determine the constructs through making comparisons.

Even though this theory is relatively old compared to more modern theories designed for data collection and analysis, Personal Construct Theory has been used in a number of studies in mathematics education (Kurz & Middleton, 2006; McQualter, 1986; Middleton, 1999; Williams, 2001). It is an appropriate and relevant theory because it provides insight into the participants' thinking and has been used for more than 50 years as a means to better understand thinking. (See Kurz [2011] for guidelines on implementing the theory into mathematics education coursework.)

Methodology

Participants

The participants were a group of 93 preservice teachers attending a university in a very diverse community in the western United States. The participants represented a diverse population with

Table 1. Steps for Data Collection and Analysis (Beail, 1985)

Step 1: Elicitation of Element(s)	Step 2: Elicitation of Constructs	Step 3: Repertory Grid Designed and Administered	Step 4: Analysis of the Repertory Grid	Step 5: Interpretation of Clusters
Video case was the only element used in this study.	Constructs were elicited using pairwise comparisons and open-ended questions.	A consensus repertory grid was created using the constructs. The grid was then administered.	The grid was analyzed using hierarchical cluster analysis via Ward's (1963) method.	Three significant clusters were determined, then described.

various cultural and socio-economical backgrounds. They were all enrolled in a mandatory mathematics methodology course for credential candidates; all were studying to be an elementary or K–12 special education teacher. Credential courses were part of a fifth-year program, meaning that most of the participants had already earned a bachelor's degree (60%); the others were dually enrolled in a bachelor's degree program and a credential program. In this particular state, students earn a degree in a subject area (usually liberal arts) before teaching courses commence. Eighty-three percent of the participants were women. In regard to their classroom experience, 11% had their own classroom and were teaching without a credential, 56% were student teaching, and the remaining 32% were not in the elementary or special education classroom.

Study Design

To collect and analyze the data, I followed the five steps that Beail (1985) described (see Table 1). First, this research was centered on video cases as the only element of investigation. With that in mind, I developed questions to elicit constructs from the preservice teachers. This involved providing all participants with questions to gain insight into their thinking in terms of video cases. The questions asked the participants to compare traditional teaching in the university classroom to using video cases. The preservice teachers were asked to describe discrepancies in their education along with ways video cases could support their development. These responses provided the constructs. Using all of the preservice teachers' responses, I created a consensus grid and then administered it to the preservice teachers. For example, a preservice teacher responded, "Books give theories and methods. Video cases allow one to study application of theories and methods." This response led to the construct *theory-aligned lessons.* Another preservice teacher stated, "[Video cases] allow additional opportunities to observe a variety of teaching styles or approaches." This became the construct *a variety of teaching techniques*. Sometimes, the constructs were rephrased based on the responses of other participants. If a construct was similar to another construct, the constructs was combined into a single construct.

There were 107 identified constructs, which I provided to the preservice teachers in a repertory grid. Essentially, a repertory grid is a table with all the constructs listed on one side and a blank for ranking each construct on the other side (see Appendix, p. 29, for a sample). The preservice teachers rated the constructs on a scale of 1–5, where a score of 1 was associated with "Would not be helpful," and a 5 was associated with "Would be extremely helpful." If any construct was left blank or improperly rated (0, for example), none of the participant's data was included in the analysis.

Data Analysis

I selected 4 (out of the original 107) constructs for analysis: (a) mathematics instruction, (b) technology instruction, (c) the use of educational tools with students, and (d) the use of manipulatives. The reason for selection of these four constructs is their alignment with the research question, as they provided insight into the use of technology, tools, and manipulatives specific to mathematics instruction. I then correlated these four constructs with the remaining 103 constructs. Using Pearson's correlation, 24 constructs were significantly correlated ($p < 0.01$) to all four of the constructs selected for analysis.

I then analyzed these constructs using hierarchical cluster analysis. Ward's (1963) method uses a Euclidean metric to determine clusters. It is designed to help minimize variance and is described as one of the better methods to create clusters (Morey, Blashfield, & Skinner, 1983). I selected Ward's method for several reasons: It is one of the more common methods used for cluster analysis, clusters are continually compared until a degenerate solution is discovered, and the clusters are easier to interpret because the method uses Euclidean distances.

Once the clusters were formed, I conducted an inverse scree test to identify the significant clusters (Lathrop & Williams, 1989, 1990). When conducting the inverse scree test, I used the agglomeration schedule. I plotted stages of the agglomeration schedule on the horizontal axis and vertically plotted coefficients from the schedule. The intersection of these two lines helped determine the number of significant points. I counted the points above the intersection to yield the number of significant clusters (Lathrop & Williams, 1989, 1990). I then analyzed these clusters for themes based on the features and descriptions of the contained constructs. Because this study used constructs that were significantly correlated at $p < 0.01$, all of the constructs within the clusters can be deemed noteworthy in relation to using tools (physical and virtual) in mathematics instruction.

Results

The inverse scree test determined three primary clusters. The first cluster focused on two particular areas of instruction. The second cluster also had two particular areas of instruction. The third cluster was quite small and contained only one construct: *how to collect and pass out materials*. Table 2 (p. 26) displays the clusters in their entirety, along with the inclusive constructs, the constructs' means, and their standard deviations.

Table 2. Constructs and Their Cluster Memberships

Video cases demonstrating…	Cluster	Mean	*SD*
How the teacher adapts the lesson based on student understanding	1	4.28	0.85
The integration of various subjects into a lesson (integrated curriculum)	1	4.10	0.94
How to reach a wide variety of learners	1	4.24	0.89
Lessons to improve my weaknesses	1	4.42	0.96
A variety of teaching techniques	1	4.42	0.84
Language arts instruction	1	3.98	1.19
Science instruction	1	3.76	1.10
Step-by-step procedures	1	3.90	1.24
Lessons to guide my strengths	1	3.79	1.21
How to use visuals in the classroom	1	3.76	1.20
Attention getters	1	3.78	1.31
Cluster 1 mean		**4.04**	**1.07**
Problem-based activities	2	3.55	1.06
Projects with students	2	3.53	1.13
How to prep activities	2	3.48	1.24
Reciprocal teaching	2	3.42	1.28
The reasoning behind the lessons	2	3.16	1.18
Group work	2	3.39	1.04
Theory-aligned lessons	2	2.97	1.21
Feedback given by the teacher	2	3.39	1.24
Expert analysis of the presented lesson	2	3.47	1.32
Time management	2	3.76	1.24
Feedback by education experts	2	3.69	1.35
Teacher reflections of the lessons	2	3.15	1.37
Cluster 2 mean		**3.41**	**1.22**
How to collect and pass out materials	3	2.37	1.26
Cluster 3 mean		**2.37**	**1.26**

Figure 1 displays the dendrogram that resulted from the hierarchical cluster analysis using Ward's method (1963). I shortened the constructs within the dendrogram due to space limitations; see Table 2 for the complete constructs. The closer the distance between two constructs, the more similar the participants viewed those constructs. For example, the distance between *how to collect and pass out materials* and *attention getters* (and other constructs in Cluster 1) appears far. This means that the participants saw these constructs as quite different. In contrast, s*cience instruction* and *language arts instruction* are close, as the participants viewed these constructs as similar. This would make sense, as they are both content areas.

Cluster 1

Cross-subject lessons emphasizing adaptations and techniques to reach a variety of learners was the topic of Cluster 1. Referencing the dendrogram in Figure 1, two primary themes were apparent. The first theme contained the first seven constructs of the cluster, starting with "how the teacher…" and ending with "science instruction" in the dendrogram. This theme focused on the complexity of teaching, including the integration of multiple subjects with mathematics. With this interrelated curriculum, there was a focus on reaching a variety of students using multiple techniques focusing on improving the preservice teachers' weaknesses. The second theme (from "step-by-step" to "attention getters") focused on lessons to guide strengths with a concentration on visuals, step-by-step procedures, and ways to get the students' attention. These concepts centered on specific techniques (for example, using visuals) to help students learn and focus.

Cluster 2

Problem-based lessons with students in groups (including preparation) supported by lesson analysis was the topic for Cluster 2. Cluster 2 also had two themes. The first theme (from "problem-based activities" to "theory-aligned lessons") focused on the problem-based group lessons with content that aligns theory with practice. In addition, video case content should include how to prepare for the lessons and the reasoning behind the lesson structure. The second theme of Cluster 2 (from "feedback given by the teacher" to "teacher reflections of the lessons") focused specifically on the need for guidance regarding the content of the video case. The preservice teachers voiced their need for help in what they were seeing within this theme. There were five identifiable constructs within this cluster that dealt specifically with analysis of the video case from different perspectives. Time management was also a concern within this cluster.

Cluster 3

The final cluster had only one construct, *how to collect and pass out materials.* This cluster is probably not a complete, comprehensive cluster. Nevertheless, it represents preservice teachers' concerns with distributing materials (tools and/or manipulatives) to students. Within the video cases, preservice teachers need to see how the tools were distributed and collected during the lesson.

Discussion and Conclusion

Use of video cases in preservice teacher education is a frequently researched theme. The reviewed research studies commonly focused on teachers' discussions, reflection, and self-reflections of video cases demonstrating teaching practices. The reviewed research findings are conclusive in regard to the positive impact video cases have on preservice teachers' professional learning and overall growth. It is apparent that the reviewed research studies focus on preservice teachers learning through the use of video cases but seldom address issues of teachers' preferences in relation to video case content. Furthermore, researchers seldom ask preservice teachers about their needs.

This research study focuses on preservice teachers' expressed needs related to video case content and design. The two primary clusters and the minor third cluster offer insight into what preservice teachers want from a mathematics video case that emphasizes physical and virtual tools to support learning. Because the preservice teachers themselves developed the constructs, they offer more insight into preservice teachers' preferences. In addition, because I evaluated only the constructs that were correlated (using Pearson's correlation ($p < 0.01$)) with the research question, the themes provide insight with a specific emphasis on needs.

The first cluster indicated that preservice teachers are concerned about the integrated teaching of multiple subjects with mathematics and the use of visuals to facilitate teaching and catch students' attention. Preservice teachers' concern in regard to cross-curricular teaching is not surprising. Cross-curricular teaching (in the context that it takes into account knowledge, skills, and understandings from various subject areas) is a real challenge for teachers, as it forces them to move from the simple use of decontextualized scenarios from other subjects (Ward-Penny, 2011). Mathematics is commonly taught as a cross-curricular subject, and several research studies indicate benefits of cross-curricular teaching of mathematics (Beckmann & Grube, 2009; Freiman, Beauchamp, Blain, Lirette-Pitre, & Fournier, 2011). For example, biology requires a sound knowledge of mathematics to discuss biological facts in meaningful ways; mathematical contexts are also enriched and given new aspects through a biological perspective (Beckmann & Grube, 2009). A study on the use of laptops in the cross-curricular learning in mathematics, science, and language arts indicated that cross-curricular teaching by use of technology may not automatically lead to better results but do create opportunities to enrich learning with more reflective and cognitively complex learning tasks (Freiman, Beauchamp, Blain, Lirette-Pitre, & Fournier, 2011).

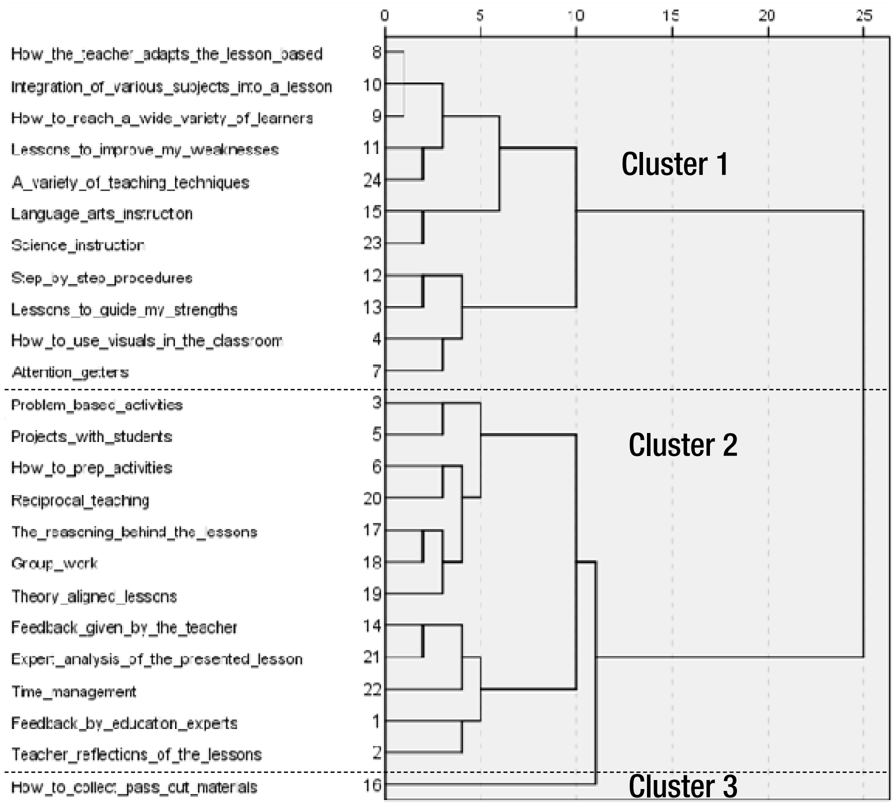

Figure 1. Dendrogram showing the significant clusters.

In the second cluster, preservice teachers recognized elements that would facilitate their own teaching, making clear connections between theory and practice and lesson preparation guidelines. In addition, they recognized the need for additional explanations of the recorded classroom practices. These expert analyses that preservice teachers discussed in Cluster 2 do not necessarily have to be a video or written analysis of the lesson. Instead, scaffolding questions that guide the analysis of the video case may be just as beneficial (Alsawaie & Alghazo, 2010; Sherin & van Es, 2005). These scaffolding questions would have to be written by the expert (the faculty member) to help improve preservice teachers' ability to notice what is taking place mathematically in the lesson. Yadav, Tyminski, Berkopes, and Zhou (2011) found that video cases do not necessarily improve preservice teachers' knowledge of reform-based mathematics without other supportive features. The participants of their study used only written reflection with the video cases while analyzing reform-based mathematics teaching. The researchers suggest that the use of reflection during class is a critical component of preservice teachers' growth.

The third cluster focused on technical issues of the distribution of educational materials and could be linked to an emerging issue of curricular materials and ways to use it in mathematics teaching. Educational materials are in close relation to the current curricular reforms, and educational material use could be linked to ways teachers engage with educational resources, the extent to which they rely on them while planning instruction, and the role of the educational materials in teachers' practice (Lloyd, Remillard, & Herbel-Eisenmann, 2009).

Revisiting the quote at the start of this paper, preservice teachers have real anxiety when entering the classroom for the first time, and video cases may be able to help. Mathematics can be particularly challenging in relation to preservice teachers' beliefs in their ability to teach and reach learners (Bursal & Paznokas, 2006). Video cases may alleviate some of that apprehension. But video cases by themselves are not the solution. Instead, instructors who design, create, and employ video cases to support preservice teachers' growth need to be sure that the cases are productively developed and used. These research findings can guide this process by providing some key components that can support video cases in mathematics education with an emphasis on tools. Cluster 2 shows the need for teaching in groups with guidance. The instructor should select cases focusing on group learning while completing problem-based activities. Then he/she should guide the preservice teachers to observe the components of the lesson that are advantageous (or disadvantageous) and why these actions lead to success (or lack of success). This direction aligns with the expert guidance preservice teachers need.

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Appendix

Sample of a repertory grid that contains only the significant constructs determined after the data analysis

Below you will find a list of ways video cases could be used to support your instruction in your preservice teacher education courses. Please rate the ways on a 1 to 5 scale. A 1 represents "would not be helpful," while a 5 represents "would be extremely helpful." Do not leave any blank.

Video cases demonstrating…	Rating
A variety of teaching techniques	
Attention getters	
Expert analysis of the presented lesson	
Feedback by education experts	
Feedback given by the teacher	
Group work	
How the teacher adapts the lesson based on student understanding	
How to collect and pass out materials	
How to prep activities	
How to reach a wide variety of learners	
How to use visuals in the classroom	
Language arts instruction	
Lessons to guide my strengths	
Lessons to improve my weaknesses	
Problem-based activities	
Projects with students	
Reciprocal teaching	
Science instruction	
Step-by-step procedures	
Teacher reflections of the lessons	
The integration of various subjects into a lesson (integrated curriculum)	
The reasoning behind the lessons	
Theory-aligned lessons	
Time management	