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Structuring Video Cases to Support Future Teachers' Problem Solving

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Abstract

This study examined preservice teachers' problem-solving skills through the use of an online video case study. Eighty preservice teachers participated in the study with a three-level video presentation by a two-grade-level between-subjects factorial design. The study incorporates a content analysis framework to examine both the components and the levels of teaching knowledge elicited during a problem-solving activity. The findings provided explanations for preservice teachers' ability to use their teaching knowledge in video-based problem solving. The elementary education preservice teachers generated pedagogical and content solutions at a higher level than the secondary education preservice teachers. This paper also discusses findings and implications. (Keywords: teaching knowledge, problem solving, video case, teacher education)

Video case studies are gaining in popularity in teacher education programs because of the difficulties in placing every preservice teacher in an exemplary classroom to develop pedagogical problem-solving skills through field experience. Yet there is a lack of sufficient empirical support to measure the impact of such tools and how they are most effectively used. Current research on the development of video classroom cases and their effectiveness indicates the need for careful scaffolding to foster preservice teacher cognition and metacognition in developing instructional strategies for ill-structured pedagogical problem solving. This includes using question prompts to guide preservice teachers' video analyses, providing multiple perspectives to enhance their problem-solving process, considering their grade-level focus to analyze their reflection, and structuring the videos based on multimedia and cognitive learning theories to help their cognitive processing of the content. This study examined how different structure designs of a video classroom case with question prompts and expert teacher perspectives played a role in preservice teachers' problem solving processes as measured by their teaching knowledge components and teaching knowledge levels.

Literature Review

Problem Solving for Preservice Teachers

Teaching constantly entails solving ill-defined problems about content, teaching strategies, technology use, or interactions with students and parents (Castro, Kelly, & Shih, 2010). Teachers encounter a variety of teaching situations that require them to make pedagogical decisions in the midst of instruction (Sherin & Van Es, 2005). Yet novice teachers find it difficult to make decisions due to their limited repertoire of teaching, lack of understanding of novel learning conditions in context (Le Maistre & Paré, 2010), or limited time to "think and act" in actual classroom settings (Szesztay, 2004). From a teacher education standpoint, such assertions underscore the importance of preparing preservice teachers to be effective problem solvers who can make effective teaching decisions on the fly when an ill-defined teaching or learning problem arises.

According to Ge and Land (2004), developing ill-defined problem-solving skills requires both cognitive and metacognitive demands. The cognitive demands entail problem solvers' (a) domain-specific knowledge and (b) organized knowledge (Ge & Land, 2004), a mental schema to interpret a given situation (Chi & Glaser, 1983; Nokes, Schunn, & Chi, 2010). While the knowledge of learner, environment, student, pedagogy, and content (Abell, 2008; Cochran & DeRuiter, 1993; Nilson, 2008) may constitute preservice teachers' domain-specific knowledge in the discipline of teaching, their organized knowledge (schemata) is a means to interpret a learning situation by connecting it to their understanding and knowledge of pedagogy.

The metacogntive demands for ill-defined problems include knowledge and regulation of cognition (e.g., what I know and how I plan and evaluate my strategies). These are considered necessary for solving ill-structured problems, especially when cognitive demands (e.g., domain-specific knowledge and schema) are limited (Pressley & McCormick, 1987). For preservice teachers, metacognitive demand in this context refers to their ability to reflect and verbalize their thinking process of solving a problematic pedagogical case (Zohar & Schwartzer, 2005).

In sum, by examining video cases that require drawing from various teaching knowledge components (cognitive) and by verbalizing their thinking process (metacognitive), preservice teachers may be better able to reason about a given teaching situation and to generate more effective instructional strategies. The following section discusses a technology-enhanced method to assist future teachers in developing such pedagogical problem-solving skills.

Video Technology for Problem Solving

An effective method to help preservice teachers become successful problem solvers is to provide guided instruction as they observe, analyze, and reflect on their own and other teachers' practices (Magnusson, Krajcik, & Borko, 1999; Nilsson, 2008). While metacognitively engaged through reflections, they will likely expand their understanding of teaching (cognitive demands) by making sense of their observations. The increased emphasis placed on field experiences in teacher education accurately underscores the importance of such activities (Allsopp, Demarie, Alvarez-Mchatton, & Doone, 2006; Ledoux & McHenry, 2004; Watzke, 2003; Willard-Holt, 2001). The difficulty in placing preservice teachers in schools that expose them to the best and most relevant practices is problematic at best. An alternative is to supplement field experiences by developing video cases that present a variety of actual teaching situations (Brush & Saye, 2007; Chaney-Cullen & Duffy, 1998; Hewitt, Pedretti, Bencze, Vaillancourt, & Yoon, 2003; Krueger, Boboc, Smaldino, Cornish, & Callahan, 2004; Stirling, Williams, & Padgett, 2004).

Video technologies have the potential to help preservice teachers identify problems encountered in classrooms and generate effective solutions to these problems through presenting various ill-structured problem scenarios and providing explicit opportunities to carefully and repeatedly examine lessons as they are taught (Wang & Hartley, 2003). However, the impact of video cases in this context is not well understood, given the dearth of empirical studies that examine preservice teacher learning from these theoretical perspectives (Wang & Hartley, 2003).

Many studies have examined preservice teachers' attitudes and feelings toward viewing video cases, but they were mainly focused on how prior experiences might shape video reflections (Barnett, 2006; Colestock & Sherin, 2009; Rand, 1998). The research literature indicates the need for considering four key factors that will allow for more rigorous analysis of video cases' potential for developing preservice teachers' higher-order cognitive and metacognitive thinking in pedagogical problem solving (Ge & Land, 2004; Rich & Hannifin, 2009; Shaw, Barry, & Mahlios, 2008; van Es & Sherin, 2006). These factors are question prompts, multiple perspectives, grade-level focus, and video structure design. Each factor is discussed in the following subsections:

Question prompts. Research findings emphasize the importance of providing explicit prompts for preservice teachers to analyze video cases as these help yield meaningful interpretation of these cases (Rich & Hannifin, 2009). Ge and Land (2004) suggested a list of question prompts aimed at scaffolding both cognitive and metacognitive skills in problem-solving activities. These prompts were developed to help activate prior content knowledge for problem identification and retrieval of appropriate solutions (cognitive), and to foster a self-regulation and monitoring process for evaluating the effectiveness of the solutions (metacognitive). Although these prompts have been effective in eliciting learners' understanding and knowledge of problem solving (Ching-Huei & Bradshaw, 2007), and thus may usefully guide preservice teachers' video analyses, some limitations exist. Learners are not likely to attend to the important aspects of the problem if they can ignore the question prompts; if their prior knowledge is insufficient, they may not be prompted effectively by the questions (Ge & Land, 2004).

Multiple perspectives. Teachers' prior pedagogical knowledge is a key to their ability to notice the important features of a learning event (van Es & Sherin, 2006). The strategies that the preservice teachers employ in response to a teaching moment usually reflects their preferred approach to teaching. This influences what they interpret from a learning event, and it likely affects their ability to notice underlying causes of a problematic case in that teaching moment, as well as to generate effective strategies connected to the key problems they identify. An effective way to address these issues is to design question prompts that support multiple perspectives of the observation (Ge & Land, 2004; Lin, Hmelo, Kinzer, & Secules, 1999). Research indicates that preservice teachers are more likely to notice different aspects of a teaching moment if they are provided with prompts that include multiple perspectives from expert teachers as opposed to being prompted to examine the situation from their own knowledge (Lampert & Ball, 1998; van Es & Sherin, 2006). Exposure to multiple perspectives drawn from expert teachers can be quite beneficial to preservice teachers, as they tend to focus on the surface features of a teaching moment (De Simone, 2008). It is likely that preservice teachers will recognize more nuanced aspects of a teaching moment by comparing their views with those of the expert teachers, rather than watching a video alone.

Grade-level focus. One of the main factors influencing the development of preservice teachers' pedagogy is their grade level (elementary vs. secondary) in their teacher education program. Existing research indicates important differences between elementary and secondary preservice teachers' approaches to teaching. Compared to secondary preservice teachers, elementary preservice teachers have been generally observed to be more aware of students' developmental abilities (Hong, 1998; Shaw, Barry, & Mahlios, 2008), prefer more frequent interactions with students (Onwuegbuzie, Witcher, Filer, Collins, Moore, & Kaufman, 2003), are more likely to adjust curriculum activities to meet students' individual needs (Behets & Vergauwen, 2004), and favor more student-centered instructional methods (Ron, McIntyre, & Norris, 1981; vonEschenbach & Ley, 1984) and assessments (Bonner & Chen, 2009). Although such differences play an important role in preservice teachers' abilities to interpret a teaching situation, grade level is not often taken into account when examining how preservice teachers solve pedagogical problems.

Video structure design. Previous research indicates the influence of scaffolding on preservice teachers' analysis of and understanding from rich digital media cases and reflects the importance of the key design factors discussed in the previous sections. Preservice teachers' reflection of the videos are enhanced by providing instruction to develop observation skills; using frameworks such as reflection questions, rubrics, or category codes to guide video reflections;

selecting a video focus aligned with the intended learning outcomes; and allowing for discussion of the videos with peers and expert teachers (Brophy, 2004; Star & Strickland, 2008; Tripp & Rich, 2011). Although further research is needed to identify the conditions that facilitate or impede the use of such strategies, an important area that is yet to be examined thoroughly is how to structure the video cases. There is particularly a gap in current research on how classroom videos and expert teachers' perspectives can be effectively structured to benefit preservice teachers' cognitive and metacognitive development of their own problem-solving processes.

Two areas of literature are particularly relevant to structuring video cases. The first is the segmenting principle in multimedia learning environments, which posits that people learn better from a multimedia message (e.g., video) when the content is presented in segments as opposed to a whole unit (Mayer, 2009). Learners can mentally organize and process both words (text or audio) and images (video or graphics) in a given segment but need a time break before the next segment to refresh their mental resources (Mayer & Moreno, 2003). This principle is supported by research that indicates the segmented content contributes to better retention and transfer skills in video (Ibrahim, 2011) and non-video-based multimedia settings (Mayer & Moreno, 2003; Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009). Although these findings are applicable in the context of well-defined problems, learners are still expected to benefit from segmented video content in solving ill-defined problems. The time breaks are particularly important for ill-defined problems because they require more cognitive and metacognitive demands (Ge & Land, 2004), leaving less mental resources for meaningfully processing a continuous information unit. As such, in the context of preservice teachers' pedagogical problem solving in a video case, the classroom video should be presented in segments rather as a continuous unit.

The second area of literature that informs the video case structure is based on cognitive flexibility theory (CFT). CFT suggests that learners gain more flexible thinking and understand a complex situation (e.g., ill-defined problems) better when given opportunities to examine it through different "lenses" (Graddy, 2001; Spiro, Collins, Thota, & Feltovich, 2003). Multiple knowledge representation (e.g., through multiple perspectives) provides the learners with "layered" resources that reveal the new and essential aspects of the situation, helping them comprehend the nature of complexity with less difficulty (Spiro, 2001). The inclusion of the case teacher's perspective in analyzing the case has been observed to act as "layered" resources uncovering the information that is not necessarily observable (Koc, Peker, & Osmanoglu, 2009). Although there is a significant gap in the literature that provides evidence of how such resources should be sequenced within a case, preservice teachers are expected to benefit more if resources are arranged sequentially. A sequential arrangement can help preservice teachers better identify the "new" information in each segment, as it offers to them a different perspective in a more timely manner. Accordingly, the case teacher's perspective, which acts as a layered resource, should be presented sequentially right after the relevant classroom video:

- Classroom segment 1: Case teacher perspective on segment 1, and *then*
- Classroom segment 2: Case teacher perspective on segment 2

This is in contrast to the presentation in which the teacher provides his or her perspective only after the classroom videos are presented:

- Classroom: Case teacher perspective *or*
- Classroom segment 1: Classroom segment 2: Case teacher perspective

Research Hypotheses

Taking into account the segmenting principle that includes the teaching knowledge components that preservice teachers draw from, and the teaching knowledge levels that they exhibit when solving a video-based, ill-defined classroom case problem, the researchers hypothesized the following (the Dependent Variables section describes the knowledge components and levels):

- **H1a:** Preservice teachers will draw from a higher amount of teacher knowledge components if the case is segmented rather than presented as a continuous unit.
- **H1b:** Preservice teachers will exhibit a higher levels of teaching knowledge if the case is segmented rather than presented as a continuous unit

The researchers also drew the following hypotheses from the Cognitive Flexibility Theory:

- **H2a:** Preservice teachers will draw from a higher amount of teacher knowledge components if the expert teacher's perspective is presented sequentially with the classroom videos rather than presenting classroom videos first followed by the expert teacher's perspective.
- **H2b:** Preservice teachers will exhibit a higher teaching knowledge level if the expert teacher's perspective is presented sequentially with the classroom videos rather than presenting classroom videos first followed by the expert teacher's perspective.

Method

Participants

Participants were fourth-year preservice teachers in the teacher education program of a mid-Atlantic university. Eighty preservice teachers participated in the study and a majority of the participants were female ($N = 71$). Forty-four participants were in elementary education and 36 were in secondary education. Participants had various specializations, including English, world languages, mathematics, general science, social studies, special education,

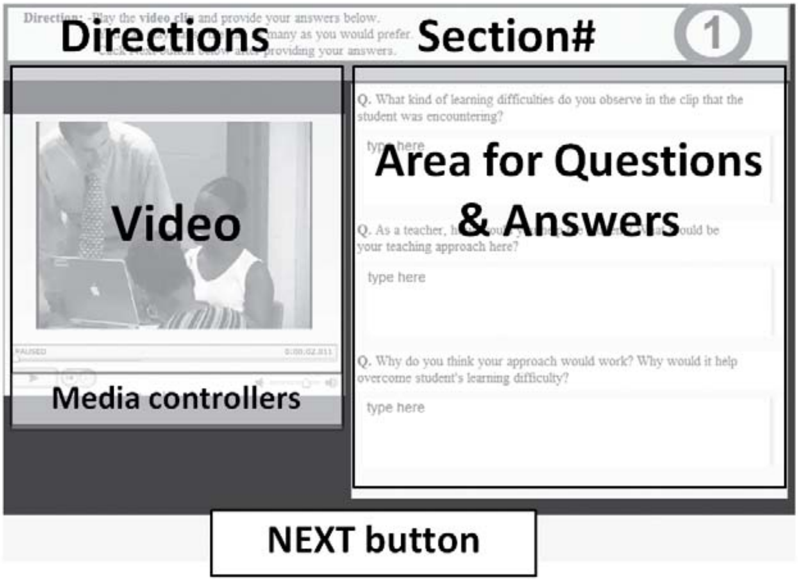

Figure 1. Video analysis interface.

and early childhood. Four research sessions were conducted in a computer classroom during the regular class time of a technology integration course focusing on alternative constructivist pedagogies. The researchers collected data across all of the four sections of the same course. Each session took approximately one hour.

Materials

Video case. The researchers selected a classroom video case that included a classroom teacher's reflections and teaching in the classroom from the website of an online professional development program called Persistent Issues in History Network (PIHnet). PIHnet attempts to enhance teachers' teaching practices by promoting problem-based learning inquiry. It has a fully developed online video library that highlights exemplary strategies employed in problem-based learning. The video case selected for the study was an 11th grade social studies lesson that involved students working in pairs to do a document analysis of a newspaper article to examine a civil rights event and to identify if there was a bias portrayed toward a group of people. We selected this case because it presented a challenging teaching moment within an alternative pedagogy where a student is having difficulty in identifying a concept.

Video analysis interface. A Flash-based interface on a Web platform displayed the classroom video case and a set of question prompts (see Figure 1).

Participants saw one of three presentation conditions with its own set of questions (see the Independent Variables section for detailed descriptions

Table 1. Comparison of Problem-Solving Stages and Relevant Questions Adapted from Literature

Ge & Land, 2004	Current Study	Question Prompts
Problem Representation/ Identification →	Problem Identification	1. What kind of difficulties do you observe in the video clip that the student was encountering?
Generating/ Selecting Solutions	Generating Solutions	2. As a teacher, how would you help the student? What would be your teaching approach in this case? 3. Based on the teacher's reflection, what issues/learning difficulties did the teacher identify? 4. What approaches do you think the teacher will take? 5. Why do you think your approach would work? Why would it help the student overcome the problem?
Making Justifications (→ Generating Solutions; → Reflection on Process)		
Monitoring & Evaluation →	Reflection on Process	6. How did the teacher help the student? 7. How is the teacher's approach different than yours that you mentioned previously? 8. Why do you think the teacher chose a different approach (if any) than yours? 9. What other approaches could you identify in the videos as to assisting the student's learning? 10. What other ways may help the student?

of each presentation condition). While answering the questions, they could replay the video by rewinding it before navigating to the next section. Once they watched all the sections and answered the section questions, their responses were automatically saved into a database for analysis.

Question prompts. There were 10 open-ended reflection questions for participants to answer as they viewed the videos. These questions were adapted from Ge and Land's (2004) work on supporting an ill-structured problem solving. As some of the stages of problem-solving process as described by Ge and Land (2004) overlapped, they were consolidated with minor alternations. We began with Problem Identification, but renamed the Making Justification stage Generating Solutions, and the final stage is Reflection on Process. In Ge and Land's (2004) work, Making Justification, where students are asked to justify their solution, is seen as a separate stage of problem solving. However, we considered it part of the Generating Solution stage, as this stage also involves similar question prompts that ask students to elaborate on their solutions. Likewise, Making Justification can also be part of the Monitoring & Evaluation stage, where the main emphasis of the question prompts is to encourage students to justify their solutions and assess alternative ones as a means to reflect on their problem-solving process. As such, we used Reflection on Process to better describe the last stage of problem solving (see Table 1).

Design

This research was a three-level video presentation (Entire, Segmented, Sequenced) by two-grade-level (Elementary, Secondary) between-subjects factorial design. The independent variables (IV) were presentation conditions and participants' focus of grade levels in teaching. The dependent variables (DV) were teaching knowledge components (Student, Environment, Teacher, and Content) and teaching knowledge

Table 2. Research Design

	IV: Presentation Conditions		
	Entire	Segmented	Sequenced
IV: Elementary	DV: Knowledge Components DV: Knowledge Levels	DV: Knowledge Components DV: Knowledge Levels	DV: Knowledge Components DV: Knowledge Levels
IV: Secondary	DV: Knowledge Components DV: Knowledge Levels	DV: Knowledge Components DV: Knowledge Levels	DV: Knowledge Components DV: Knowledge Levels

levels (Surface, Isolated, Integrated, and Transformed) elicited during the preservice teachers' problem-solving activity (see Table 2).

Independent Variables

Entire video presentation. This presentation consists of two sections. In the first section, participants watched a classroom video that presents a learning situation in which a student is having difficulty understanding a concept, and the classroom teacher is assisting the student. Participants answered six questions (questions 1, 2, 5, 6, 7, and 8) while watching the video. The questions were designed to elicit their process of problem solving, particularly the stages of Problem Identification, Generating Solutions, and Reflection on Process. After providing their answers, participants navigated to the second section, where they watched a reflection video of the classroom teacher that presents the teacher's perspective on the difficulty that the student encounters and his pedagogical decisions. Participants answered two questions (question 9 and 10) designed to elicit Reflection on Process.

Segmented video presentation. This condition has three sections. In the first section, participants watched only a part of the classroom video that presents a segment where the student is having difficulty understanding a concept. In contrast to the previous presentation condition, how the classroom teacher approached the situation is not part of the clip. Participants answered three questions (question 1, 2, and 5) designed to elicit their process of problem solving, particularly the stages of Problem Identification and Generating Solutions. They then watched the remaining part of the classroom video in the second section that shows the classroom teacher assisting the student and concurrently answered three questions (question 6, 7, and 8) designed to elicit Reflection on Process. In the final section, participants watched the teacher's reflection video and answered two questions (questions 9 and 10) designed to elicit the Reflection On Process.

Sequenced video presentation. There were four sections in this presentation condition. As in the previous condition (Segmented), participants started watching only the first part of the classroom video that shows the student having difficulty understanding a concept. Again, how the classroom teacher approached the situation is not part of this segment. The participants answered three questions (question 1, 2, and 5) that were designed to elicit their process of problem solving, particularly the stages of Problem

Table 3. Comparison of Presentation Conditions

Conditions	Timeline: Section 1 →	Section 2 →	Section 3 →	Section 4
Entire	Entire classroom video Six questions*	Entire reflection video Two questions		
Segmented	Classroom video segment 1 Three questions	Classroom video segment 2 Three questions	Entire reflection video Two questions	
Sequenced	Classroom video segment 1 Three questions	Reflection video segment 1 Two questions	Classroom video segment 2 Three questions	Reflection video segment 2 Two questions

Identification and Generating Solutions. In the second section, participants watched only the first part of the reflection video that presents the teachers' reflection on the difficulty the student encounters. The remaining part of the classroom teacher's reflection, which was on how he helped the student, was not part of this clip. The participants answered two questions (questions 3 and 4) designed to help recall the student's learning difficulty that the teacher identified in the reflection clip and the teacher's subsequent actions in the following clips. In the third section, participants watched the remaining part of the classroom video and answered three questions (question 6, 7, and 8) designed to elicit their Reflection on Process. In the fourth section, they watched the remaining part of the reflection video, which presented the teacher's perspective of how he assisted the student, and answered two questions (questions 9 and 10) designed to elicit their Reflection on Process. This section is different than those in the previous two conditions. Participants received only the second part of the reflection video, whereas those in the previous two conditions viewed the entire reflection video at once. See Table 3 and Table 4 for comparison of the conditions.

Dependent Variables

Teaching knowledge components. Shulman's (1986) work on pedagogical content knowledge (PCK) informs this study, but we adapted the concept of teaching knowledge components as an initial framework (student, environment, teacher, content) because it is an effective framework for shedding light on preservice teacher knowledge components and knowledge levels (Abell, 2008; Cochran & DeRuiter, 1993; Nilson, 2008). The separate knowledge components were easier to operationalize because they are more specific than PCK and still constitute pedagogical knowledge, content knowledge, and pedagogical content knowledge. For instance, teacher knowledge, which deals with teaching strategies, procedures, and evaluations; and environment knowledge, which is about contextual factors or classroom management issues, can be considered part of pedagogical knowledge in PCK. Likewise, student knowledge, which deals with student abilities, prior knowledge, or developmental levels, can be a dimension of pedagogical content knowledge, which Shulman (1986) defines as the understanding of "conceptions and

Table 4. Comparison of Presentation Conditions Described

Conditions	Timeline						
	Section 1	→	Section 2	→	Section 3	→	Section 4
Entire	Watch entire classroom video • Learning problem • Teachers' approach Answer 6 Qs (1, 2, 5, 6, 7, 8) • Problem identification • Generating solutions • Reflection on process		Watch entire teacher's reflection • Learning problem • Teachers' approach Answer 2 Qs (9 & 10) • Reflection on process				
Segmented	Watch classroom video part 1 • Learning problem Answer 3 Qs (1, 2, 5) • Problem identification • Generating solutions		Watch classroom video part 2 • Teacher's approach Answer 3 Qs (7 & 8) • Reflection on processs		Watch entire teacher's reflection • Learning problem • Teachers' approach Answer 2 Qs (9 & 10) • Reflection on process		
Sequenced	Watch classroom video part 1 • Learning problem Answer 3 Qs (1, 2, 5) • Problem identification • Generating solutions		Watch teacher's reflection part 1 • Learning problem Answer 2 Qs (4 & 5) • Recall • Expectations		Watch classroom video part 2 • Teacher's approach Answer 3 Qs (7 & 8) • Reflection on process		Watch teacher's reflection part 2 • Teacher's approach Answer 2 Qs (9 & 10) • Reflection on process

pre-conceptions that students of different ages and backgrounds bring with them to the learning" (p. 9).

By employing a quantitative content analysis technique (Bauer, 2000; Herring, 2004), we categorized preservice teachers' responses to these synthesized knowledge components: student, environment, teacher, and content (see Table 5, p. 188).

The researchers analyzed participants' answers for the problem-solving stages, as demonstrated in Table 1. We analyzed the answers to questions 1, 2, and 5 for the Problem Identification and Generating Solutions stages and analyzed the answers to questions 6, 7, 8, 9, and 10 for the Reflection on Process stage. We developed this approach of focusing on a set of answers because the preliminary analysis revealed that participants' responses might demonstrate different problem-solving stages than those that the questions

Table 5. Teaching Knowledge Components

Category	Indicators	Examples
Student	Student abilities, attention, prior knowledge, or developmental levels	The student was having a hard time understanding the difference ... she does not understand the vocabulary or context clues, which is probably because this is above her reading level.
Environment	Physical and social contextual factors, regulations, classroom management	The teacher took that approach perhaps due to time constraints or maybe since he knew the student much more than I do from just watching the video.
Teacher	Teaching strategies, planning, teaching procedures, evaluation	The teacher could have written down some of the information, or underlined, bolded, or in some way highlighted the information needed to answer the question.
Content	Teaching particular content, knowledge of concept difficulty	I would probably try and have her draw on her previous knowledge of race relations in the South, especially Mississippi where biases were everywhere in regards to the Civil Rights Movement.

were designed to elicit. For instance, when answering the questions that seek solutions generated for the problem (e.g., "How would you help the student?"), some participants provided reasons presenting their perceptions of the problem, which supported or further elaborated on their answers to the earlier questions. Similarly, when asked about problem identification, some participants mentioned solutions in their answers.

Participants' answers to questions 3 and 4, which were asked only in the Sequenced condition, were excluded from the analysis to avoid a potential confounding factor effect. These questions served to direct participants to review the clip, segmented only in the Sequenced condition, before they moved to the next section. They were not needed in the other two conditions because they had already viewed this video as part of the teacher's entire reflection video.

Teaching knowledge levels. Preservice teachers' level of teaching knowledge was indexed by the amount of integrated knowledge components identified at the stages of the problem-solving process. The categories for knowledge levels emerged as we began analysis of the data and learned from the discussion about the differences between novices and experts in the work of Bransford, Brown, and Cocking (2000) and Shulman's (1986) concept of transformation of content for teaching. The analysis revealed four ordinal levels: (0) Surface, (1) Isolated, (2) Integrated, and (3) Transformed (see Table 6). Participants were considered as demonstrating a Surface level of teaching knowledge if their answers were not related to any knowledge component (student, environment, teacher, or content). They were considered to have an Isolated level of teaching knowledge when they drew from only one knowledge component in their answers. On the other hand, they demonstrated an Integrated or Transformed level of teaching knowledge when their answers represented more than one knowledge component. The level of teaching knowledge was considered Transformed only if one of the knowledge components was content related. Such categorization emphasizes that the effective transformation of content for teaching (Shulman, 1986)

Table 6. Coding Scheme for Scoring Teaching Knowledge Levels in Problem Solving

	Teaching Knowledge Levels			
Problem-Solving Stages	Surface (0)	Isolated (1)	Integrated (2)	Transformed (3)
Problem Identification (PI) Qs (1,2,5)	No link to cause	Link to causes related to one type of knowledge component only	Link to causes related to more than one type of knowledge component	Link to causes related to more than one type of knowledge component including content knowledge
Generating Solutions (GS) Qs (1,2,5)	No solution provided or solutions not linked to problem	Provide solutions representing one type of knowledge component only	Provide solutions representing more than one type of knowledge component	Providing solutions representing more than one type of knowledge component including content knowledge
Reflection on Process (ROP) Qs (6, 7, 8, 9, 10)	No reflection provided on the solution process	Reflection on the solution process by comparing alternatives and/or elaborating on them based on one type of knowledge component only	Reflection on the solution process by comparing alternatives and/or elaborating on them based on more than one type of knowledge component	Reflection on the solution process by comparing alternatives and/or elaborating them based on more than one type of knowledge component including content knowledge

requires a deep understanding and interpretation of the subject matter (Bransford et al., 2002; Cochran & DeRuiter, 1993; Nilsson, 2008).

These categories are on an ordinal scale, reflecting rank-ordering data. Transformed teaching knowledge is the highest on the scale. Integrated knowledge indicates a lower level, as the multiple knowledge components identified would have no reference to content, unlike at the Transformed level. The Isolated level, on the other hand, is considered lower than the Integrated level, as it would represent one knowledge component only. Lastly, Surface knowledge, which is not related to any of the knowledge components, specifies the lowest level.

Procedure

Participants in each session were in their regular classrooms (four sections of the same course) and completed the activities as part of their course requirements. The first author, who was also one of the instructors, attended all of the sections, including his own, to introduce the activity, and the section instructors provided technical support and helped answer student questions. He randomly gave all participants one of three URLs (connecting to one of the three presentation conditions) on a sheet of paper, which he drew from a bag. He asked the participants to complete the video analysis individually via their assigned URL. As they answered the questions, the responses were automatically saved into a database for analysis. The unit of analysis for categorizing knowledge components was meaning (thematic unit) observed within a set of responses. The authors individually coded the responses of 30 randomly selected participants and achieved 85% intercoder reliability. After establishing the categories with the acceptable level of intercoder reliability score, one of the co-authors coded the remaining data.

Table 7. Mean Scores and (Standard Deviations) of Teaching Knowledge Levels by Content Area

Stages of Problem Solving	Content Area	Average Teaching Knowledge Level and (SD)	$p > 0.05$
Problem Identification	Others	1.24 (0.61)	0.95
	Social Studies	1.00 (0.00)	
Generating Solutions	Others	1.82 (0.78)	0.68
	Social Studies	1.64 (0.93)	
Reflection on Process	Others	1.76 (0.46)	0.95
	Social Studies	1.79 (0.58)	

Initial Analysis of Content Areas

As described previously, participants had various content specializations, and the video case used in the study involved social studies content only. As such, an analysis of how participants' content-area preparation would influence the results was warranted. The researchers conducted a series of ANOVA tests comparing the average number of teaching knowledge components and average teaching knowledge levels at each stage of problem solving. The results indicated that content specializations did not influence the amount of teaching knowledge components the participants drew or the teaching knowledge level they exhibited at any stage of problem solving. There was no statistically significant difference between social studies majors ($N = 14$) and non-social-studies majors ($N = 66$) regarding teaching knowledge components and teaching knowledge levels at any stage of problem solving. Table 7 shows the differences between the groups in terms of teaching knowledge levels.

Results

Teaching Knowledge Components

Content analysis revealed that 403 units of meaning were identified in all the answers. Of all the knowledge components, the majority were categorized as Teacher ($N = 171$, 42%), followed by Student ($N = 147$, 37%), Environment ($N = 57$, 14%), and Content ($N = 28$, 7%) respectively across all the stages of the problem-solving process. Figure 2 shows the frequency of each of these knowledge components observed in the responses.

In the majority of the responses ($N = 78$, 79%) during the problem identification stage, participants drew from the Student knowledge component. Most identified the problem as the student not understanding the meaning of a concept (bias) in the document analysis. They mentioned the student's inadequate comprehension levels and lack of prior knowledge as the major causes of the problem. Few responses linked the causes to Environment, Teacher, or Content knowledge components.

On the other hand, when generating solutions, participants provided answers that represented the Teacher knowledge component ($N = 81$, 57%). These initial solutions consisted of various teaching strategies and planning

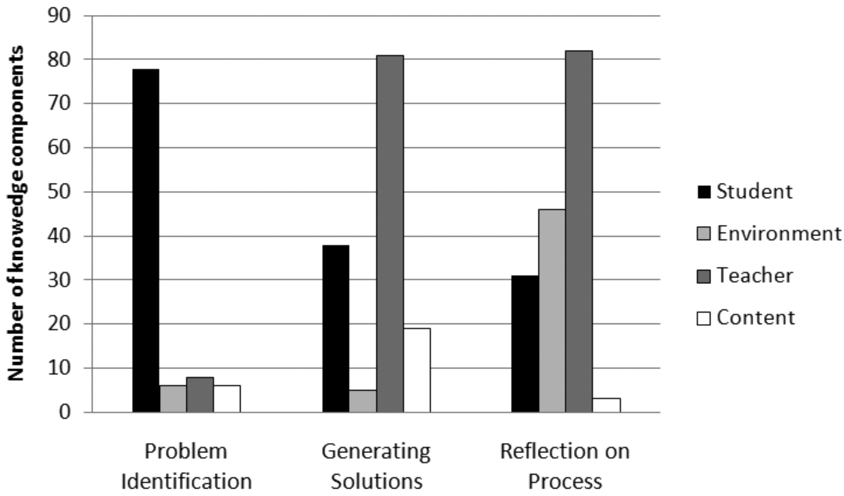

Figure 2. Number of knowledge components during the stages of problem solving.

about giving prior mini-lessons, scaffolding, questioning, and providing examples. Also, in more than a quarter of the solutions generated ($N = 38$, 27%), participants explicitly emphasized how the proposed solutions can specifically address the student's needs, reflecting the Student knowledge component. Only 16% of the responses represented Content and Environment knowledge components ($N = 19$, $N = 5$ respectively).

When asked to reflect on their solutions by considering and comparing alternative ones, participants focused on the teaching strategies half of the time (Teacher knowledge) ($N = 82$, 51%). Compared to previous stages, however, they drew more from the Environment knowledge component. More than a quarter of the time ($N = 46$, 28%), participants referred to potential time constraints, the lack of available resources in the classroom, and their lack of knowledge about the student and classroom context. Although participants continued to emphasize the student's needs in their reflection ($N = 31$, 19%), 1% of the responses included content-specific solutions ($N = 3$).

To test the hypotheses H1a and H2a focusing on teaching knowledge components, we conducted a series of two-way ANOVA tests comparing the average number of each knowledge component elicited at the stages of problem-solving process[1]. The findings did not support research hypothesis H1a, which predicted a higher amount of teaching knowledge components in segmented classroom videos. There was no significant difference in the amount of any knowledge component observed between Entire Video Presentation and Segmented Video Presentation at any stage of problem solving.

The findings partially supported research hypothesis H2a, which predicted a higher amount of teaching knowledge components in presentations where

1 The use of MANOVA was not suitable due to the strong theoretical relationships among stages of problem-solving process.

Table 8. Mean Scores and (Standard Deviations) of Teaching Knowledge Components by Grade Level

	Presentation Conditions		
Grade Levels	Entire	Segmented	Sequenced
Elementary	0.00 (0.00)	0.00 (0.00)	0.07 (0.26)
Secondary	0.29 (0.47)	0.00 (0.00)	0.00 (0.00)
Total	0.15 (0.36)	0.00 (0.00)	0.04 (0.19)

the case teacher's perspective is sequentially presented for each classroom video segment. The results indicated a significant main effect of the conditions on only the Environment knowledge component during the Reflection on Process stage ($F(2,74) = 4.76$, $p = 0.011$) The partial η^2 (0.114) was comparable to Cohen's (1988) notion of moderately large effect size. The post hoc comparisons using Bonferroni[2] test revealed that participants in Sequenced Video Presentation ($M = 0.77$, $SD = 0.65$) utilized a significantly higher amount of Environment knowledge than those in Entire Video Presentation ($M = 0.33$, $SD = 0.48$) with a p-value of 0.014, when reflecting on process. However, no significant difference was observed between Sequenced Video Presentation and Segmented Video Presentation at any stage of problem solving.

The results also indicated a significant interaction between the type of presentation conditions and participants' school teaching level on the amount of Environment knowledge component when they generated solutions ($F(2, 74) = 4.522$, $p = 0.014$). The partial η^2 (0.109) was of medium to large size (see Table 8).

The presentation conditions had little effect on elementary preservice teachers. However, secondary preservice teachers generated solutions with a higher amount of Environment knowledge component in Entire Presentation than when they were in the other two conditions (see Figure 3).

The Entire Presentation condition benefited only secondary preservice teachers in terms of generating solutions based on Environment knowledge. Thus, the research hypotheses H1a and H2a, which predicted a higher amount of teaching knowledge components in segmented and sequenced video case presentations, were rejected due to the findings pertaining to secondary preservice teachers.

Teaching Knowledge Levels

We determined the levels of teaching knowledge using the coding scheme (Table 6) and the scoring (Surface-0, Isolated-1, Integrated-2, and Transformed-3), which was based on the amount and type of knowledge components identified in the responses. We calculated participants' scores and then averaged them within the stages of problem solving (see Table 9, p. 194).

Overall, the results showed that at any stage of the problem-solving process, participants' teaching knowledge level was between Isolated (1)

2 To avoid a possible Type 1 error due to multiple ANOVAs, we chose the Bonferroni test, as it provides comparisons at an adjusted-lowered alpha value.

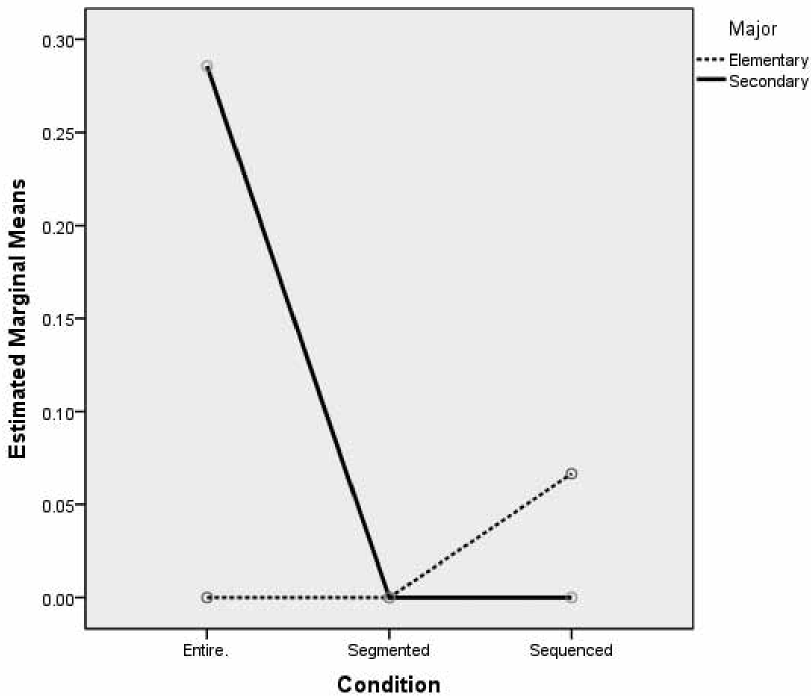

Figure 3. Average amount of Environment knowledge during generating solutions.

and Integrated (2) on average. They exhibited relatively higher yet partially Integrated teaching knowledge levels when generating solutions and reflecting on process than when identifying problems.

To test the hypotheses H1b and H2b focusing on teaching knowledge levels, we conducted a series of two-way ANOVA tests. Table 10 shows the average teaching knowledge levels of both elementary and secondary preservice teachers in each presentation condition during the stages of the problem-solving process.

The findings did not support research hypothesis H1b, which predicted a higher teaching knowledge level in segmented classroom videos. We did not observe any significant difference between Entire Video Presentation and Segmented Video Presentation regarding the average teaching knowledge level that participants exhibited at any stage of problem solving. On the other hand, findings partially supported research hypothesis H2b, which predicted a higher amount of teaching knowledge levels in presentations where the teacher's perspective is sequentially presented for classroom videos. The results indicated a significant main effect of presentation conditions on participants' teaching knowledge level only when they reflected on the process ($F(2,74) = 3.83$, $p = 0.026$). We observed the effect size (partial $\eta^2 = 0.094$) to be medium to large. Post hoc comparisons using the Bonferroni test revealed that participants in the Sequenced Video Presentation ($M =$

Table 9. Mean Scores and (Standard Deviations) of Teaching Knowledge Levels at Stages of Problem Solving

	Problem Identification	Generating Solutions	Reflection on Process
M	1.2	1.79	1.76
(*SD*)	(0.56)	0.80	(0.48)

Table 10. Means Scores and (Standard Deviations) of Teaching Knowledge Levels at Stages of Problem Solving by Conditions and Grade Levels

Stages of Problem Solving	Grade Levels	Presentation Conditions			
		Entire	Segmented	Sequenced	**Total**
Problem Identification	Elementary	1.23 (0.59)	1.44 (0.81)	1.13 (0.35)	**1.27** **(0.62)**
	Secondary	1.21 (0.58)	1.00 (0.00)	1.09 (0.54)	**1.11** **(0.47)**
	Total	**1.22** **(0.58)**	**1.26** **(0.66)**	**1.12** **(0.43)**	
Generating Solutions	Elementary	2.23 (0.83)	1.88 (0.81)	1.93 (0.78)	**2.00** **(0.81)**
	Secondary	1.57 (0.65)	1.64 (0.92)	1.36 (0.67)	**1.53** **(0.76)**
	Total	**1.89** **(0.80)**	**1.78** **(0.85)**	**1.69** **(0.79)**	
Reflection on Process	Elementary	1.46 (0.52)	1.87 (0.62)	1.93 (0.26)	**1.77** **(0.52)**
	Secondary	1.64 (0.49)	1.82 (0.41)	1.82 (0.41)	**1.75** **(0.44)**
	Total	**1.56** **(0.51)**	**1.85** **(0.53)**	**1.88** **(0.33)**	

1.88, *SD* = 0.33) had a significantly higher teaching knowledge level than those in the Entire Video Presentation (*M* = 1.56, *SD* = 0.51) during the Reflection on Process stage (see Figure 4).

Regarding the main effect of grade levels, elementary education majors demonstrated a significantly higher teaching knowledge level (*M* = 2.00, *SD* = 0.83) than did secondary education majors (*M* = 1.53, *SD* = 0.74) when generating solutions ($F(1,74) = 7.625$, $p = 0.007$). The partial η^2 (0.093) indicated a medium to large effect size (see Figure 5, p. 196).

No significant interaction effect was observed between the presentation conditions and the focus of grade level at any stage of problem solving.

Discussion

This study explored the ways preservice teachers make sense of a structured video case with question prompts during a problem-solving activity. Findings warrant the further discussion of four themes.

Content Matching Video Case

Overall, preservice teachers in this study reached Isolated and Integrated levels of teaching knowledge during the video-based problem-solving

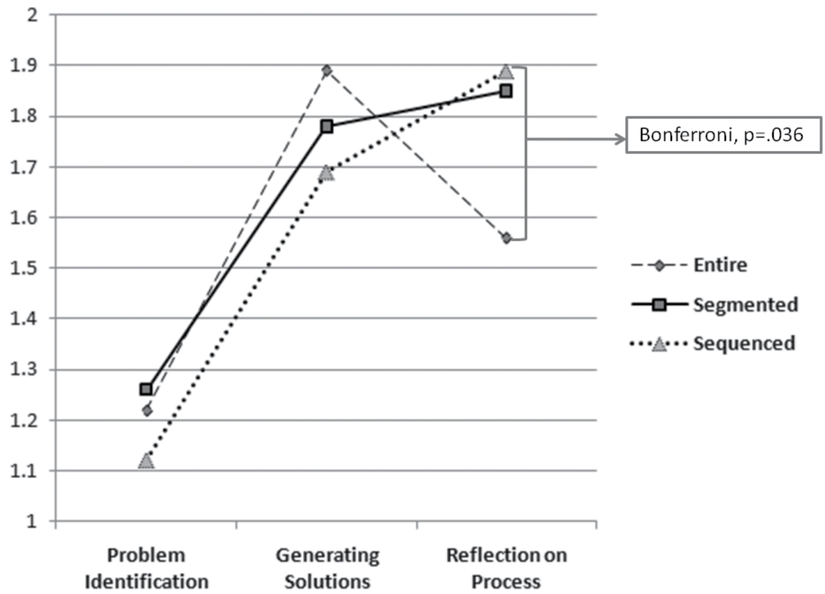

Figure 4. Teaching knowledge by condition during problem solving.

activity. This finding indicates that, although the participants drew from at least one teaching knowledge component at any stage of the problem-solving process, they rarely used their content knowledge. We also observed this in the analysis of individual teaching knowledge components, which revealed that content knowledge was least frequently observed in participants' responses (7%).

These findings were influenced by the fact that only 18% ($N = 14$) of the participants were majoring in social studies. Given the relatively small number of participants with a social studies background, the question prompts in any presentation condition may have not elicited a sufficient amount of social studies content knowledge components, lowering the average level of teaching knowledge observed. A higher number of participants majoring in social studies would be necessary to statistically examine the impact of the presentation conditions in future research.

Segmenting Videos

As indicated, the findings did not support research hypotheses H1a and H1b, which predicted a higher amount of knowledge components and higher knowledge levels in segmented classroom video presentations. Based on the segmentation principle, participants were expected to make better sense of the segmented presentation, as they likely have more resources to allocate for information processing. However, we observed no significant

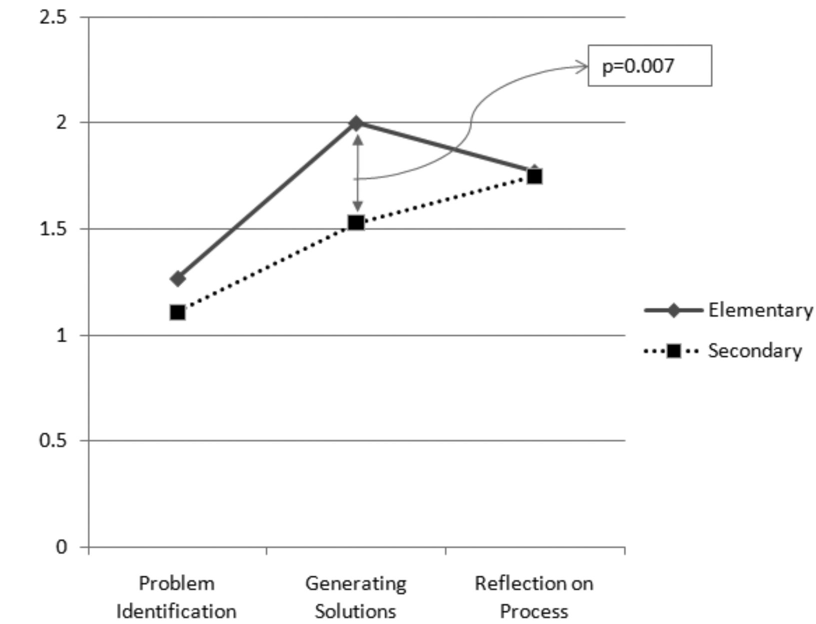

Figure 5. Teaching knowledge levels by school teaching level during the stages of problem solving.

difference between the Entire presentation and the Segmented presentation. We considered two explanations for this finding.

First, the classroom video presented in the study may not be complex enough to require high cognitive and metacognitive demands from the participants, leaving enough mental resources for them to still process the information meaningfully if they were to view the video continuously (Entire). The case teacher constantly demonstrated one-to-one interaction with the student, during which he used questioning techniques to identify the student's learning difficulty. As it may be easy for participants to recognize such explicit teaching, presenting it continuously may not necessarily cause "less" mental resources for the meaningful processing of the remaining video content.

Second, watching the entire video may have still helped participants understand the complexity of the case more holistically, negating the easy processing of its segmented pieces. The classroom and the teacher reflection videos were presented "as is" in the Entire presentation, whereas the classroom video was segmented into two parts (problem and solution) in the Segmented presentation. Seeing the problem and the case teacher's solution continuously may be more beneficial than seeing the problem first, then the solution separately (Segmented). Being exposed to the teacher's solution immediately after the problem may have acted as a "more timely" layered resource, helping participants consider the causes of the problem that the student was encountering and the possible solutions to handle it from a different point of view. In contrast, the lack of complexity and entirety of the classroom case may have prevented participants from gaining such an additional perspective, even though they may have easily processed the content of the segmented video.

Sequencing Videos

The presentation conditions made a difference for eliciting Environment knowledge at the Reflection on Process stage. Particularly, the Sequenced presentation was more effective than the Entire presentation in encouraging participants to consider contextual factors when they considered alternative instructional solutions, supporting research hypotheses H2a and H2b, which predicted a higher amount of knowledge components and a higher knowledge level in presentations where teacher perspective is presented sequentially with the classroom videos.

As expected, the Sequenced presentation may have provided participants with "a more timely" alternative perspectives through sequencing the teacher's reflection video with the relevant classroom videos. During the second section of this presentation condition, participants watched the teacher reflect about the student's learning difficulty (reflection video part 1) and offered potential solutions. This may have prompted them to think about the student's learning difficulty differently and led them to consider alternative solutions that would not have occurred to them otherwise. With more solutions to consider and compare, participants may have been prompted to draw from more knowledge components, increasing their teaching knowledge levels at the Reflection on Process stage.

Focus of Grade Level

Regardless of the presentation conditions, elementary education majors demonstrated a significantly higher level of teaching knowledge than did secondary education majors at the Generating Solutions stage. Elementary education majors were better than their secondary education counterparts in terms of drawing from various knowledge components simultaneously (Student, Environment, Teacher, and Content) when they generated solutions.

Although further research is needed to examine such differences, various emphases of teacher education programs for each major may provide possible explanations. Whereas elementary education programs may stress instructional methods, secondary education programs may be more content focused (vonEschenbach & Ley, 1984). Also, field placement experiences tend to be more extensive for elementary majors than for secondary majors, who spend more time in subject-focused placement classrooms (Parkison, 2008). Such disparities have been analyzed in various research studies, which indicated that elementary education majors were more likely than secondary education majors to adjust curriculum activities to meet students' needs (Behets & Vergauwen, 2004) and to favor more student-centered instructional and assessment methods (Bonner & Chen, 2009; Ron et al., 1981;

vonEschenbach & Ley, 1984). Likewise, elementary education majors in this study may be more knowledgeable about diverse instructional techniques, whereas secondary education majors may be conditioned to employ whole-classroom instruction in teaching content areas. When it comes to generating potential teaching strategies for a student-oriented teaching situation, the elementary education majors may have had more to say due to their greater knowledge of diverse learner-centered instructional strategies and developmental differences of individual learners.

Two main differences regarding participants' program of study and field experiences support this assertion. First, prior to this study, both groups of participants had completed the same teaching education courses focusing on learning, technology, and differentiated instruction, except for one class in language arts and literacy that was offered to elementary majors only. Although this course provided the basic foundations of language learning, it required participants to teach small groups of students at one of the placement schools. Such an additional field experience may have offered elementary majors the opportunities to interact directly with students in group instructions, possibly contributing to their understanding of teaching strategies for various individual learning needs.

Second, since 2005, the Response to Intervention (RtI) programs in West Virginia, which aim to promote differentiated interventions based on the careful monitoring of student learning progress, had been planned for and implemented at elementary schools only (West Virginia Response to Intervention Project, 2005). These initiatives had emphasized inservice teachers' skills and knowledge on effectively identifying students' learning needs and tailoring their instruction accordingly to help students who struggle to learn (West Virginia Response to Intervention Project, 2011). Working with mentor teachers at placement schools who had been trained to implement RtIs with such a focus may have broadened elementary majors' student-centered teaching approaches.

Another finding observed between elementary and secondary majors in this study highlights the need for further research into the differences between the two groups. The analysis revealed that presentation order had little effect on elementary education majors' ability to demonstrate more complex problem-solving skills. However, the Entire presentation seemed to benefit secondary education majors to a great degree. Thus, we rejected the hypotheses H1a and H2a, which predicted a higher amount of teaching knowledge components and teaching knowledge levels in segmented and sequenced presentations, only for the findings about secondary preservice teachers. When generating solutions in the Entire presentation condition, secondary education majors were more likely than elementary education majors to draw from Environment knowledge, although overall this group did not score as well as the elementary students.

This finding may be related to different teaching approaches that each group tends to employ. As observed in previous studies, compared to elementary education majors, secondary education preservice teachers used less frequent interactions with students (Ongwuegbuzie et al., 2003) and chose more teacher-centered instructional methods (Ron et al., 1981; vonEschenbach & Ley, 1984). Similarly, secondary education majors in this study may be more inclined to favor teacher-led practices, such as lecturing. As such, when they viewed the entire classroom video presentation, they may have been more concerned with problems such as classroom management issues from a whole-class instruction perspective. On the other hand, secondary education majors may have gained a student-centered perspective from the video because it demonstrated a student-oriented teaching approach. Seeing the teacher working with the individual student extensively may have prompted them to consider student-centered strategies in addition to the teacher-centered ones they already had in mind when generating solutions. As seen in a representative quote from a secondary education participant below, almost two-thirds of the secondary education majors ($N = 25$) identified differences between their strategies and the classroom teacher's strategies, reflecting their focus on a whole-classroom teaching perspective:

> The teacher should teach more about point of view. He did do a mini-lesson for the student so that they could understand more about bias. I think that my approach is similar, however, if this student was having this problem, then maybe other students were having the same problem.

In contrast, seeing the teacher's approach separately in the later segmented clip (Segmented) or hearing about the teacher's perspective on the student's difficulty before seeing the teacher's approach (Sequenced) may have not prompted them to consider such differences, given that they were asked to generate solutions in the early sections of the presentation conditions.

Implications

This research study has important implications regarding teacher education program design and video case structure for supporting preservice teachers' problem solving.

Teacher Education Program

The current study confirms previous research in terms of the possible discrepancies between elementary and secondary education preservice teachers' approaches to teaching. As found, due to their possible greater knowledge of diverse learner-centered strategies, elementary education majors were able to generate solutions exemplifying a higher level of teaching knowledge than that of secondary education majors' solutions.

This finding stresses the modeling of diverse instructional methods and the implementation of extensive field placements that expose secondary education majors to more student-oriented teaching situations. Whereas the former strategy entails the development of teacher education courses focusing on alternative instructional strategies for individual learning needs, the latter suggests state-initiated programs such as RtIs at the secondary education level, which would allow more student-oriented placement opportunities for preservice teachers.

Video Case Structure

The findings illuminated how the classroom and teacher reflection videos with question prompts may be structured. First, this study recommends that the teacher reflection videos be segmented as a means of directing preservice teachers to think about the observed teaching/learning problem differently and to prompt them to use multiple knowledge components when considering effective instructional solutions. Participants were better able to consider factors such as contextual issues when comparing alternative teaching strategies if they were exposed to the teacher's reflection sequentially. By hearing from the teacher's perspective about the student's learning difficulty and reflecting on potential solutions, they were able to draw from more knowledge components, including contextual factors, than when they heard from the teacher about both the problem and his solution. The latter case seemed to limit participants' responses to the teacher's perspective of his instruction, as they immediately viewed the teacher's approach without being prompted to think about it first.

Second, the findings indicated that the decision for segmenting classroom videos should take the presented teaching situation into account. As observed, segmenting the classroom video (problem and solution) did not necessarily influence how participants drew from teaching knowledge. One of the reasons for this observation was the lack of case complexity due to the explicit teaching observed in the video, possibly making the processing of the continuous information easy. Segmenting the classroom video may be more effective to support preservice teachers' problem solving if the video case presents a more complex case (e.g., less explicit teaching strategy), pushing them to consider different alternative solutions in their case analysis.

Another reason for the non-significant positive effect of segmentation was the ability to consider the student's learning difficulty and the possible strategies to handle it from a different point of view when reviewing the case more holistically (Entire). Watching the entire classroom video was even more beneficial than watching the first part to secondary education majors' ability to generate solutions. Viewing the learning problem and the teacher's student-oriented approach reminded secondary education majors of contextual issues that the teacher could have considered from a teacher-led classroom perspective. In contrast, viewing the first part of the classroom video without clearly observing the teacher's strategies limited their ability to recognize differences between their own and the teacher's possible solutions. Thus, as a third strategy, the study suggests segmenting the classroom videos based on the differences between the participants' preferred teaching approach and the one demonstrated in the case. Showing both the problem and the teacher's approach in one classroom video may be more effective than segmenting it if the case highlights a teaching strategy that preservice teachers may not be familiar with or are unlikely to employ in their practices.

Future Research

There is a need to continue testing and adapting synthesized frameworks with different participants and subject matter. The case in this study is about social studies, making the findings more applicable to a history domain. Such contextual factors should be taken into account when employing the framework in, or applying the findings to, other teacher education settings. Conducting research based on the same design at multiple teacher education institutions would help validate the findings for preservice teachers at different programs. Furthermore, future studies may consider in-vivo experimental research design options where participants complete the video case analysis with extended times in their own contexts instead of in a classroom setting. Given the increased online aspects of teacher education, particularly in field placement, such a design approach can bring about authentic and rigorous research results.

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