2016 NCTM RESEARCH CONFERENCE
April 11-13 • San Francisco

Paper Title: Examining Preservice Teachers' Ability to Problem Pose in Response to Common Core Aligned Videotaped Math Lessons

Author(s): Christina Eubanks-Turner, Anita Kreide

Session Title: Using Video to Prepare Preservice Teachers to Pose Purposeful Questions

Session Type: Brief Research Report

Presentation Date: Tuesday, April 12, 2016

Presentation Location: San Francisco, California

Examining Preservice Teachers' Ability to Problem Pose
in Response to Common Core Aligned Videotaped Math Lessons

Christina Eubanks-Turner[1], Anita Kreide[2]
Loyola Marymount University, Los Angeles, CA, 90045
[1] Seaver College of Science and Engineering, Department of Mathematics
[2] School of Education, Center for Math and Science Teaching

Abstract

The study explores mathematical problem posing abilities in a mathematics content course for preservice elementary school teachers K-6. This study documents preservice teacher problem posing in written responses related to Common Core aligned videotaped math lessons, as a means to gain understanding of preservice teachers' mathematical content knowledge. Through multi tiered coding analysis relational to the exemplar videos we discuss implications of this work to mathematical content courses for pre-service elementary teachers.

Keywords: problem posing, preservice teacher, teacher education, depth of knowledge, exemplar modeling, mathematical knowledge for teaching

Introduction

According to the Partnership for 21st Century Skills chaired by the National Education Association (NEA), educators are tasked with teaching skills such as critical thinking, collaboration, communication, innovation, problem solving, and creativity (Partnership for 21st Century Skills, 2015). To develop 21st century higher-order skills, many researchers agree that questioning can be used as a powerful instructional tool (Blumenfeld et al., 1991; Brophy & Good, 1986; Legg, 1971). Latham (1997) notes that questioning is used not only for students' assessment but also engages students in higher-order thinking processes that stimulate their curiosity. In the National Council of Teachers of Mathematics (NCTM's) Principles to Action, posing purposeful questions has been noted as an effective teaching practice used to "assess and advance students' reasoning and sense making about important mathematical ideas and relationships" (NCTM, 2014). Therefore, it is important that preservice teachers (PSTs) are provided with the necessary experience, time and context to develop questioning techniques before they are involved in teaching students.

Mathematical Problem Posing (MPP) occurs when students create new questions or problems or when students reformulate problems from a given one (Silver, 1994). There is much work that shows the benefit of MPP in mathematical teaching and learning (Kilpatrick, 2001; NCTM, 2000; Hadamard, 1945; English, 2003). For instance, studies have shown that a student's ability to problem pose relates to a student's use of problem-solving strategies (Cai, J., Hwang, S., 2003; Cifarelli & Cai, 2005). Christou et al. (2005) describe the cognitive process involved in problem posing. The model involves the following processes: editing quantitative information, their meanings or relationships; selecting quantitative information; comprehending and organizing quantitative information; and translating quantitative information from one form to another (Christou et al., 2005). In Mathematical Problem Posing (2015) Singer et al. give a comprehensive overview of mathematical problem posing highlighting many aspects such as problem posing related to mathematical problem solving, problem posing in school mathematics curriculum and problem posing in teacher education and professional development.

While some researchers have focused on the problem posing abilities of K-12 students (English, 1997; Silver & Cai, 1996; Ball & Forzani, 2009) others have analyzed problem posing in teacher education (Gonzalez, 1998; Crespo, 2003; Grundmeier, 2015). Crespo (2003) reported on the change in preservice elementary problem posing practices in a mathematics teacher education course. Gonzalez gives a "blueprint" to facilitate both teachers and teacher educators in problem posing. Most relevant to this study is the work is the work of Leung & Silver (1997) and Grundmeier (2015).

Leung and Silver (1997) examined arithmetic problem posing behaviors of sixty-three preservice elementary teachers. They found that most of the preservice teachers were able to pose solvable problems and that problem posing ability was better when the task contained numerical information. In the study mentioned above, Leung and Silver created classifications of problem-posing responses, which we will utilize and adapt for the current study. In more recent work that extends Leung, Silver's and others work on problem posing, Grundmeier (2015) considered how preservice elementary teachers generated and reformulated problems from given information. Grundmeier's study involved 19 prospective teachers in a mathematics content course for teachers. He showed that problem posing ability can be developed further by engaging preservice teachers in a form of problem posing in mathematics courses for teachers. Grundmeier and others also call for a need for math teacher educators to further extend work on mathematical problem posing and include problem posing activities in classes for future teachers (Grundmeier, 2015; Gonzalez, 1994; Silver et al., 1996).

Responding to Grundmeier's call, the work in the current study examines the problem posing abilities preservice elementary teachers in a mathematics content course for prospective elementary and middle school teachers. In an effort to address the concerns of researchers who feel there is a need for more work to understand how preservice teachers develop their content knowledge (Thanheiser et al., 2013), this work aims to explore problem posing as a means to gain understanding of teachers' mathematical content knowledge (English, 1997) and investigate the relationship between teachers' perception of their own mathematical content knowledge with their ability to problem pose. As the work calls for preservice teachers to problem posing by modifying or extend a given task, this work also investigates preservice teachers' Mathematical Knowledge for Teaching (MKT), in particular the Specialized Content Knowledge (SCK) domain (Ball, Thames, Phelps, 2008).

Teacher educators have used both amateur and professionally developed video focused on mathematics teaching and learning (Boling, 2007; Lampert & Ball, 1998; Sherin, 2004). Researchers have used video to foster productive mathematical discussions (Borko et al., 2008), improve noticing and observation skills (Star & Strickland, 2008; Sherin & van ES, 2005) and to prepare PSTs for field experiences (Santaga & Zannoli, 2007; Llinares & Vallas, 2009). Therefore, videos allow preservice teacher not in the classroom to observe student responses and interactions with pose probelms. With this classroom context in mind preservice teachers can begin to consider how students will react to the problems they are posing. Teachers can then see real time problem solving allowing them to make the connection to problem posing (Bonotto & Santo, 2015).

Although many have had success using video-supplemented instruction in PST coursework, some researchers documented concerns regarding the range of technical skills among PSTs and access to technical tools (Friel & Carboni, 2000; Rhine & Bryant, 2007). For this study, problem posing from a video lesson has been documented as a useful source in promoting teacher learning. Although in most problem posing scenarios learners are given written tasks (Crespo, 2003; Grundmeier, 2015), this study expands on the type of scenarios by giving the preservice teacher video that encompassed exemplar mathematical lessons, where students could fully observe all the information given. Also video is more desirable than in person classroom observation as PSTs are given time to reflect on what they have watched and view it many times to aide in their problem posing. Also, as this analysis took place as a part of a mathematical content course for teachers, video was chosen to give preservice teachers models of exemplar teaching.

Another aspect of this study is to examine preservice teacher mathematical confidence in association with their mathematical problem posing abilities. Research has shown the importance of learners' attitudes and beliefs about mathematics for their achievement in math (Ernest, 1991). Also, many researchers have shown that teachers' self-efficacy and attitudes toward math has an affect not only on teacher learning, but also their teaching (Riggs and Enochs, 1990; Ernest, 1988). For example, Ma (1999) found attitudes and lack of confidence toward math affected teachers' willingness to problem solve with students. Bromme and Brophy (1986) noted that teachers model their attitudes and beliefs while they are teaching, which has an affect student attitudes and learning. Researchers have shown that preservice teachers have high levels of mathematics anxiety (Battista, 1990, Bursal & Paznokas, 2006). Researchers also call for the teacher education community to better understand the links between teacher beliefs and practices (Gresham, 2010; Stipek et al., 2001).

Methodology

Participants and Course

The study took place in Spring 2015 during the second course (two-course sequence) of a mathematics content course (algebra, geometry and statistics) for elementary teachers. Participants included 26 PSTs, two sections of the same course, who consented to being a part of the study including only freshmen and sophomores in their first year of the preparation program. PSTs names were coded to protect their identity. The instructor of the course was not involved in the study, but agreed to let the researchers examine student work. There was no instruction given on mathematical problem posing.

Video description

The PSTs were assigned to watch two video clips of master teachers lessons on the website teachingchannel.org. The study utilized this site because it is open-access and known for displaying videos of effective teacher practices and common core math content/MPs. Content from two grade levels (grades 3 and 8) were represented in the videos. Below are descriptions of the two videos:

The first (pre-instruction intervention) video "Conjecturing about Functions" is nine minutes containing a lesson in an eighth grade class where students are analyzing patterns to represent functions (https://www.teachingchannel.org/videos/conjecture-lesson-plan). Students then made conjectures about the patterns of functions. Each pattern included three rows with stacks of dots that increased from left to right and varying starting/ending markers. Students were then asked to share conjectures as a group and speak through their evidence and reasoning for the conjectures. The class then critiqued the reasoning of their classmates. Video one included Common Core State Standards Mathematical Content (CCSS) 8.F.B.4:

> Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values, including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values (NGA, 2010).

This video elicits mathematical practices including to reason abstractly and quantitatively (MP2) and construct viable arguments and critique the reasoning of others (MP3) (NGA, 2010).

The second (post-instruction intervention) video "Table for 22: A Real-World Geometry Project" is a fourteen minute video containing a lesson given in a sixth grade class where students apply knowledge of area and perimeter to solve a real-world problem of seating the 22 students in the class around a rectangular table and can be accessed at https://www.teachingchannel.org/videos/real-world-geometry-lesson. Video 2 included the Common Core State Standards Mathematical Content (CCSS) Math.3.MD.C.7b and Math.3.MD.D.8:

> Multiply side lengths to find areas of rectangles with whole-number side lengths in the context of solving real world and mathematical problems, and represent whole-number products as rectangular areas in mathematical reasoning. Solve real world and mathematical problems involving perimeters of polygons, including finding the perimeter given the side lengths, finding an unknown side length, and exhibiting rectangles with the same perimeter and different areas or with the same area and different perimeters (NGA, 2010).

This video elicits mathematical practices including to model with mathematics (MP4) and construct viable arguments and critique the reasoning of others (MP3) (NGA, 2010).

Data collection

During the semester, each video was given as information in a problem posing assignment, which was apart of a homework assignment. For each assignment, after watching each video PSTs were asked to give a written response to the following prompt:

> Write a question that a teacher could ask a student to help expand or deepen the students' knowledge about the mathematical ideas being discussed. Explain why the question will help to expand or deepen the students' mathematical knowledge and tell which common core domain and mathematical practice the question is aligned with. Have you seen this video before? Rank on a 1-10 scale your level of confidence with the math content in the video?

Leung and Silver (1997) states "Problem posing refers to both the generation of new problems and the re-formulation, of given problems. Thus, posing can occur before, during, or after the solution of a problem." The type of problem posing referred to in this study occurs prior to problem solving as students have to pose a problem based on a video lesson they watched about two topics: pattern conjecturing about functions and perimeter and area of a rectangle. For clarity we modify working definitions given by Grundmeier (2015), which are given in the table below.

Table 1

Working Definitions

Term	Working Definition
Problem	A mathematical question for which a valid

	solution exists.
Problem Reformulation	The process of posing a problem related to a problem that is or was the focus of problem solving.
Problem Generation	The process of posing a problem based on a set of given information. Generated problems may include additional information to the original set but must be related to the original set of information.
Problem Deepening (Expansion)*	The process of posing a problem with the same (if DOK 3 or higher) or higher (if DOK 2 or lower) cognitive demand level related to a problem that is or was the focus of problem solving.

*In the student prompt we used the phrase "expand or deepen" to instructor students on the type of problem we would like them to pose. The word "expand" is used here only as a synonym for deepen. It does not hold any relevance to our investigation. Also, the video was set at the highest cognitive level to offer the students an exemplar model, thereby setting the bar at the highest level in the hopes more students would reach a higher level themselves as a result. DOK refers to "Depth of Knowledge", which is explained in the next section.

Additionally, we asked students to rank their confidence level of the mathematical content in the video to better understand preservice teachers beliefs about their mathematical confidence and to also see if this confidence level correlated to their mathematical problem posing ability. When assigning the prompt, the instructor told the students that a 1 represented no confidence, 5 represented neutral and 10 represented very confident. As these tasks were assigned for research purposes, students received completion grades on this part of the assignment.

Problem Generation Coding

In this study an adaption of Leung and Silver's (1997) generation coding was utilized, while considering quantitative scores given by Grundmeier (2015). Coding was completed using the three dimensions: plausibility, sufficiency and depth of knowledge. Unlike the two previously mentioned generation coding schemes, depth of knowledge (DOK) was considered because the problem posing task we assigned asked students to construct a "question that a teacher could ask a student to help expand or deepen the students' knowledge about the mathematical ideas being discussed." As Webb's depth of knowledge framework is known as a tool used to classify cognitive depth (Webb, 1997) in tasks, we felt depth of knowledge levels would give the most accurate measure of the cognitive depth in each of the posed problems. In Webb's framework cognitive demand is measured in incremental levels defined as recall (DOK 1), skills/concepts (DOK 2), strategic thinking (DOK 3), and extended thinking models (DOK 4) (Hess, 2009; Webb, 1997). As we also wanted to investigate the appearance of content issues, we came up with the following flow chart for generation coding.

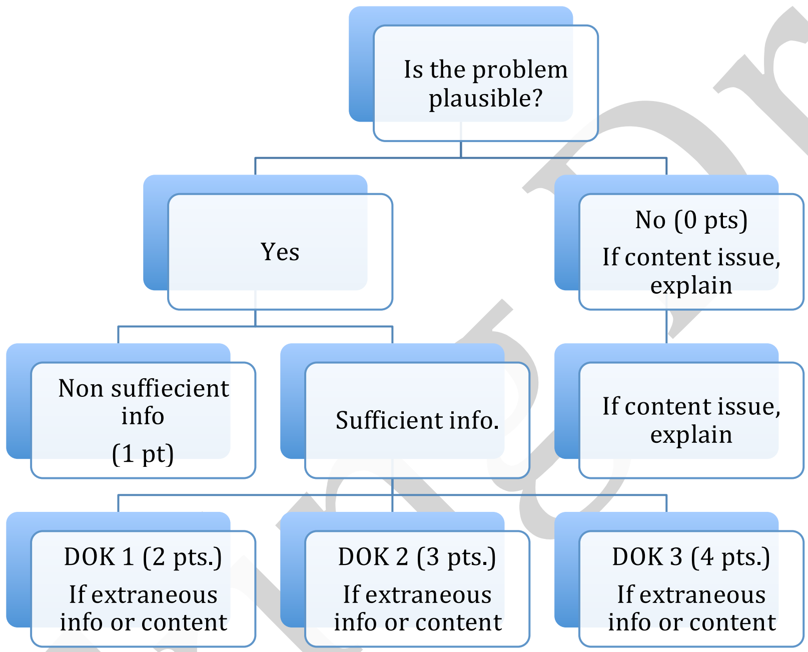

Figure 1 Problem generation flow chart

Reformulation coding

To better understand the relationship with the problem posed and the mathematical content of the video, reformulation categories were coded as in the table below. In this study four reformulations were added, as some of the posed questions did not adhere to the original categories given in Grundmeier (2015). The categories added include: same as video, contextualized component, complex content, and content not related. Further description of each reformulation is provided in Table 2 below. As indicated in the category descriptions there is also a code of either a 0 or 1. A zero denotes reformulations that require a lower level of creativity and understanding of the mathematical content such as reword, same as video, contextualized a component, or content not related to the video. A one represents reformulation techniques that involve more creativity and a greater level of understanding the mathematical content such as switching the given and the wanted, changing the context, changing the given, changing the wanted, extending the problem, adding information, and complex content.

Table 2

Reformulation Criteria Coding

Category	Description
1.Switch the given and the wanted (1 pt)	Same problem context with given and wanted switched
2. Change the context (1 pt)	A problem with the same structure but different context
3. Change the given (1 pt)	Same problem context and structure but the given is changed
4. Change the wanted (1 pt)	Same problem context and structure but the wanted is changed
5.Extension (1pt)	An extension of the given problem
6. Add information (1 pt)	Same problem context and structure with added information
7. Re-word (0 pt)	Same problem with different wording
8. Same as video (0 pt)	Same problem exactly as asked in video
9. Contextualized component (0)	Used one structural component in different context
10. Complex context (1)	Changed context, more complex structure
11. Content not related (0)	Problem not related to video topic

In order to increase interrater reliability four researchers (two authors, one undergraduate and two graduate researcher) independently scored PST responses and reached agreement based on the analysis of the following criteria: problem generation, problem reformulation, overall coding matrix, DOK level of exemplar videos, and PSTs question DOK level. To determine the DOK in the exemplar videos each was watched in thirds and three coders rated each section for DOK level with the final DOK level representing the modes of all three sections of the video. Both video lessons were rated at DOK level 2, with video 1 (conjectures) moving into a DOK 3 in the last third of the video. The decision to utilize DOK 2 exemplar videos was made to allow PSTs to have the opportunity to extend into a DOK 3 level. Consistent with Leung and Silver (1997 and Grundmeier (2015) high levels of inter-rater agreement on coding generation and reformulation were seen.

Results

Table 3
Problem Generation Data

	Posed Problems	Plausible	Sufficient Information	DOK 1	DOK 2	DOK 3
Video 1	35	30 (86%)	29 (83%)	9 (31%)	18 (62%)	2 (7%)
Video 2	39	35 (90%)	26 (67%)	13 (50%)	11 (42%)	2 (8%)
Overall	74	65 (88%)	55 (74%)	22 (40%)	29 (53%)	4 (7%)

Table 3 represents the number of pre-service teachers' (PSTs) who posed problems (n= 74) for each of the 2 exemplar videos. Some teachers posed multiple problems for each prompt. As problems were generated based on the content topic in video 1 and 2, about an equal number of PSTs were able to pose plausible problems with an overall average percentage of 88%. Of the plausible problems 16% more PSTs were able to include sufficient information for problems created from video 1 compared to video 2. Cognitive difficulty measured in depth of knowledge (DOK) was based on posed problems that had sufficient information to be solved. For video 1 (n=29) 69% of the problems reached the DOK 2 or 3 level of difficulty, compared to 50% for video 2 (n=26); a 19% decrease in problem posing difficulty from video 1 to video 2.

It is interesting to note that video 1 covers the eighth grade standard of conjectures with functions while video 2 contains a third grade standard on area and perimeter. PST's were able to reach a higher DOK level 19% more in problems generated at the higher (8th grade) standard level. One possible explanation is PST's most recent content covered in their mathematics coursework is functions as opposed to geometry. Another explanation is that video 1 allowed PSTs to see the transition from a DOK 2 level to DOK 3 level in terms of conjectures. Video 1 began asking students to make conjectures about functions (DOK2) and extended the questions into justifying conjectures (DOK 3). It is possible that showing the transition to a higher cognitive level allowed 19% more PSTs to reach higher cognitive levels in their questions. Thus, supporting the idea that setting a higher bar allows for more individuals to reach a higher point than if the bar had been set at a lower level.

Table 4
Problem Reformulation Data

	Video 1	Video 2	Overall
Plausible Problems	n= 30	n=35	n=65
Switch the given and the wanted	0	2 (6%)	2 (3%)
Change the context	0	4 (11%)	4 (6%)
Change the given	4 (13%)	6 (17%)	10 (15%)
Change the wanted	7 (23%)	0	7 (11%)
Extension	9 (30%)	10 (29%)	18 (28%)
Add information	1 (3%)	2 (6%)	3 (5%)
Re-word	7 (23%)	2 (6%)	9 (14%)
Same as video	1 (3%)	0	1 (2%)
Contextualized a component	1 (3%)	5 (14%)	6 (9%)
Complex context	0 (0%)	1 (3%)	1 (2%)
Content not related	3 (3%)	1 (3%)	4 (6%)

In table 4 above posed problems were coded into reformulation categories. These categories are adapted from Grundmeier (2015) and Leung and Silver (1997) as they were determined to be valid and reliable by the authors. In this study four reformulations were added, as some of the posed questions did not adhere to the original categories. The categories added include: same as video, contextualized component, complex content, and content not related. Further description of each reformulation is provided in section 4 above. As indicated in the category descriptions there is also a code for either a 0 or 1. A zero denotes reformulations that require a lower level of creativity and cognitive demand such as re-word, same as video, contextualized a component, or content not related to the video. A one represents reformulation techniques that involve more creativity and a greater level of mathematical understanding such as switching the given and the wanted, changing the context, changing the given, changing the wanted, extending the problem, adding information, and complex content. The use of the 0 and 1 codes will be seen later in data table 5 below. In these codes 31% of problem reformulations coded at a value of zero, indicating a low cognitive demand level with 69% reaching higher understanding levels.

In both videos 1 and 2 the most common reformulation at 28% was the extension of the problem as well as changing the given at 15%. This shows that students were trying to extend their problem into reaching higher levels of cognitive demand as modeled in the videos. The most common decrease in cognitive demand level in video 1 and 2 reformulation at 14% was re-wording the problem, which occurred 23% in video 1 as opposed to 6% in video 2.

To show the two dimensions of PSTs problem posing (generation and reformulation) table 3 below indicates the integration of both components into the coding matrix. A zero indicates that in both generation and reformulation (see table 5 below) the problem posed is not plausible. For a plausible problem that does not have sufficient information to complete, a overall code of one was given. Codes of 0 and 1 indicate the lowest cognitive level of problem formation as they cannot be performed by a student. A code of two refers to a plausible problem that does not have sufficient information to complete but fits into reformulation category 1-6 or 10. A code of 3 is a problem at a DOK 2 with a lower cognitive level of reformulation (see asterisk below) or a lower DOK 1 level with a higher cognitive level of reformulation. A code of 4 indicates a DOK 2 level with a higher cognitive level of reformulation or a DOK 3 level with a lower cognitive level of reformulation. The highest matrix code at 5 is a DOK 3 level with a higher cognitive level of reformulation.

0-5 Coding Matrix for Overall Generation and Reformulation Problem Analysis

0	Non plausible problem
1	Plausible with sufficient information
2	Plausible with non sufficient info and reform category 1-6 or 10 Or DOK 1 reform category 7-9, 11
3	DOK 2 reform category 7-9, 11 DOK 1 reform category 1-6 or 10

4	DOK 2 reform category 1-6 or 10 DOK 3 reform category 7-9, 11
5	DOK 3 reform category 1-6 or 10

* reform is abbr. for reformulation data; category 7-9,11 indicates lower level cognitive demand; category 1-6 or 10 indicates higher level cognitive demand

Subjecting problems to multi stages of analysis beginning with generation, reformulation, and finally applying a comprehensive problem code (0-5) allows for the convergence of multiple lenses to offer a clear picture of PSTs problem posing ability. The table below is the overall data from PSTs and shows the relationship between the depth of knowledge reached and approach to reformulation of the video problem. The highest cognitive level is accessed in the combination of DOK 3 and reformulation 1-6 or 10 for code 5. Therefore both cognitive depth and approach towards problem creation determine overall cognitive demand. The data indicates that 57% of PSTs were able to reach a level 3 or higher while 42% were in the 0-2 range.

Table
Overall Problem Generation and Reformulation Data

	0	1	2	3	4	5
Video 1 n=35	5 (14%)	1 (3%)	4 (11%)	14 (40%)	9 (26%)	2 (6%)
Video 2 n=39	4 (10%)	5 (13%)	12 (31%)	5 (13%)	9 (23%)	4 (10%)
Overall n=74	9 (12%)	6 (8%)	16 (22%)	19 (26%)	18 (24%)	6 (8%)

Content Knowledge Concerns[1]

As a one of the goals of this research is to see if there are any links between problem posing ability and content knowledge, we analyzed teacher responses, both the problems they posed and their explanations, for content concerns. As the Mathematical Knowledge for Teaching (MKT) framework divides content or subject matter knowledge in three subdomains: Specialized Content Knowledge (SCK), Horizon Content Knowledge

[1] Add data analysis of PSTs' content knowledge trends

(HCK) and Common Content Knowledge (CCK), we discuss content knowledge concerns in light of these subdomains (Ball, Thames, Phelps, 2008). In this study, we did not have any students display HCK concerns.

Specialized Content Knowledge (SCK) Concerns

In both videos we noticed trends where students posed problems and gave explanations to "why the question will help to expand or deepen the students' mathematical knowledge" having SCK concerns. As SCK is described as "the mathematical knowledge and skill unique to teaching" (Ball, Thames, Phelps, 2008). Here we display student work that involves a SCK concern of a particular kind that was a common trend in our data. This SCK concerned involved students posing problems that involved mathematical complexities far beyond the mathematical ideas demonstrated in the video. For example, in video 2, a student posed the

"the teacher could ask the students to use different shapes (pentagon, hexagon, etc.) to make the table. This would deepen and expand the children's knowledge of area and perimeter because the student's would then understand how perimeter and area are related, even when the shapes are different".

This problem demonstrates the student's lack of knowledge of the process it takes to find the area of complex polygons like pentagons and hexagons. As the student assumes that the only given information is "the shape has a perimeter of 22 yards", as in the video, the student does not realize to solve this problem with the given information and either a pentagon or hexagon involves trigonometric functions. Even if the PST assumed one could solve the problem using the skill described in Common Core Standard CCSS.MATH.CONTENT.6.G.A.1(Find the area of right triangles, other triangles, special quadrilaterals, and polygons by composing into rectangles or decomposing into triangles and other shapes; apply these techniques in the context of solving real-world and mathematical problems), there was not sufficient information to solve the problem.

To demonstrate a problem posed from a student who possesses SCK related to this video we have the following example,

"how would they find the area if the table was now the shape of a right triangle?" As the student states in the problem "if the table was NOW the…", we assume the student takes the perimeter as 22 yards as in the video. Note this student's use of a right triangle, which has the special feature of altitude being one of the sides of the triangle allowing the student to utilize the area formula for a triangle.

Common Content Knowledge (CCK) Concerns

Ball, Thames and Phelp (2008) describe Common Content Knowledge (CCK) as "mathematical knowledge and skill used in settings other than teaching" (Ball, Thames, Phelps, 2008). This is a content knowledge that is not tied to teaching. In our study we discovered several instances where students lacked CCK. Specifically, we observed many instances where students incorrectly used common mathematical terms. For example, in video 1 one student posed a problem by asking "Looking at the different groups, how do the equations differ and how are they the same? How does this affect the plot on the graph? " When the student asks the second question and refers to the "plot of the graph", this student is incorrectly using plot as a noun and not a verb.

In video 1, we did not see as much misuse of terms as we did in Video 2, which we were surprised by since, the terms in video 2 are more common and are typically thought of as less complex. For example, one student posed the following problem related to video 2, "For an art project, Mike needs to fil his whole canvas board with paint. This canvas board is 25 inches wide and 12 inches tall. How much square inches is Mike going to take up if he paints this whole canvas board?" Considering the problem posed above, there is no content knowledge concern. However, from the student's explanation of "why the question will help to expand or deepen the students' mathematical knowledge", the student writes "In this video, the teacher tries to create math problems out of real-world situations. More specifically, she emphasizes on the subject or perimeter and area. So for my question, I decided to create a situation where students have to find the surface area of a rectangle." This demonstrates the student's confusion with difference in the notions of area and surface area in mathematics.

The next response gives an example of a student who posed a plausible problem that expanded the mathematical ideas seen in video 2. While the problem posed received a score of 4 for generation and reformulation coding since the problem is a DOK level 2 extension problem, as written, the problem does not reveal any content knowledge concerns. However, the student's explanation of "why the question will help to expand or deepen the students' mathematical knowledge" shows the students lack of understanding between the difference in surface area and volume. See the Figure Below

Problem Posed: We discovered that we needed to have a 5ft by 6ft table made by the carpenter for our last meal. When the carpenter made the table, he had to make it sturdy enough to hold all the food securely on top, so he made it 1 ft thick (or gave it a height of 1ft.) Now that we have had our thanksgiving meal, a plastic covering needs to be cut by the teacher so that it can wrap around the table to preserve it while it is in storage until next year. How many square ft of plastic wrap does the teacher need to cover the entire table?
Explanation: This question would satisfy the sixth grade common core standard

6.G.A.2, "Apply the formulas V = l w h and V = b h to find volumes of right rectangular prisms with fractional edge lengths in the context of solving real-world and mathematical problems" found under the "geometry" domain...this question would deepen and expand on the student's knowledge of area and give them a challenging example of area in a third dimension: volume.

Figure: Student response related to Video 2

Here the student does not understand the difference between the two-dimensional concept of surface area and three-dimensional concept of volume. We the PIs feel this student could have benefited from trying to solve the problem he/she posed to see that it did not involve volume. We also feel it is notable that this particular student had an awareness of extending in the context of curricular standards by trying to extend to a sixth grade content standard involving three-dimensional rectangular prisms (recall, the students in video 2 were sixth and the teacher felt they needed remediation on the concepts of area and perimeter), thus demonstrating their Pedagogical Content Knowledge in the domain of Knowledge of Content and Curriculum (Shulman, 1987). As this video assignment was given to PSTs after the concept of surface area had been taught in the content course, we the researchers assume this may be a factor attributing to the appearance of many problems extending to problems concerning surface area.

Table
Pre Service Teacher Reported Confidence Level

	Video 1	Video 2	Overall
Confidence 1-10 scale (10 most confident)	n= 29	n=34	n=63
Level 1	0	0	0
Level 2	0	0	0
Level 3	2 (7%)	0	2 (3%)
Level 4	2 (7%)	0	2 (3%)
Level 5	0	0	0
Level 6	5 (17%)	2 (6%)	7 (11%)
Level 7	9 (31%)	5 (15%)	14 (22%)
Level 8	4 (14%)	7 (21%)	11 (17%)
Level 9	2 (7%)	8 (24%)	10 (16%)
Level 10	1 (3%)	7 (21%)	8 (13%)
Not stated	3 (10%)	5 (15%)	8 (13%)

Confidence level and related content knowledge concerns

In both videos students were asked to rate their confidence level with the Common Core Mathematics Standards taught in the exemplar videos on a 1-10 scale, with 10 representing the highest confidence level as seen in table above. The first video contained the eighth grade Common Core Mathematical Standard 8.F.B.4 which asks students to use functions to model relationships between quantities. The second video contained the third grade Common Core Mathematical Standard 3.MD.C.7b and 3.MD.D.8 to apply knowledge of area and perimeter to solve a real-world problem. Across both videos a little over three quarters of the students self-rated their confidence level from 1 to 4 points lower on the eighth grade content compared to the third grade content, showing more confidence in lower grade level content. This aligns with our prior study in which content level concerns increased as Standards progressed from a first to fourth grade level (Kreide, Eubanks-Turner & Tomlinson, 2015). Direct concerns with content knowledge were expressed in response to video 1, with the eighth grade standards as seen below in the PSTs response to the video prompt:

> Video 1: I still to this day get a tad confused with which variable makes the graph skinny, upside down, positive, and what not (PST, 2015).

> Video 1: I didn't really know what she was talking about with what a conjecture is, though I would be able to make a plot graph with those patterns rate of change? (PST, 2015).

A trend in responses indicated that some PSTs were able to identify their own content concerns after having watched the exemplar videos. Thus, suggesting teachers could benefit from watching exemplar teaching not only for pedagogy, but for acknowledgment and development of content standards. This is seen in responses to both videos below:

> Video 1: after watching the video, I realized that there were many different ways to approach this content and I have no clue (PST, 2015).

> Video 2: Before this video, I thought I had a solid understanding about the concept of area and perimeter, but it's clear that there are so many different ways to incorporate these concepts into questions (PST, 2015).

Along with identification of content concerns some PSTs indicated their confidence with the eighth grade standards had increased after having watched the exemplar video 1. It is noteworthy that for the third grade content (video 2) an increase in content confidence was not noted by the respondents. This models our previous study where content knowledge concerns were seen in a fourth grade video, but not in a first grade video possibly indicating the need for more PST content coursework with advancing grade levels (Kreide, Eubanks-Turner & Tomlinson, 2015). PSTs samples of increased confidence through watching exemplar video 1 are below:

> "Before watching this video and learning about functions in class, I would have ranked myself as a '3' in terms of how well I understood functions. However, after watching the video and referencing back to my previous knowledge on functions and what I learned in class, I believe I am a '7' in terms of my confidence in the subject" (PST, 2015).

"To be honest, my level of confidence with the math content in the video was a 7. Initially, I was unsure of a conjecture and its meaning, however, as the teacher and other students explained the relationships and what they were doing with the clumps of dots, I picked up quickly" (PST, 2015).

In the samples above it is particularly interesting to see that one PST noted a 4 point increase in topic confidence and the other "picked up quickly" content knowledge after watching one exemplar video. How fast can PSTs content knowledge improve by watching an exemplar teaching video focused on mathematical pedagogy and questioning? How much influence does pedagogy have on PSTs content knowledge acquisition? Can content knowledge support come from exemplar videos displaying pedagogy through content?

As is seen in the sample above our prior and current studies put forward the idea that rigorous mathematical questioning by PSTs is less likely as content standards increase in difficulty from first to eighth grade. One possible argument for this trend is that content knowledge limits the ability of the respondents to develop questions at the strategic thinking level (DOK 3) modeled in video 1 and 2 of this current study. This idea is illustrated in the response below:

> " I would have to rate it at a 8. I understand the sequences and graphing I just found it very challenging to come up with a question that fits the conversation so I believe I have more reviewing to do to be more comfortable with the material" (PST, 2015).

Trends indicating other content knowledge concerns possibly involved in PSTs ability to form purposeful questions were seen in the varied alignment between the question posed, confidence level indicated, and content knowledge displayed by the PSTs. For example, one respondent seen below for video 2 showed consistency in that their confidence was midscale (6) and content knowledge concerns were reflected in their question.

Rating: 6- I am very comfortable with area and perimeter, but the challenge tricked me and make me need time to think about how I could find the biggest table and the smallest table

Problem Posed: A new challenge related to this problem would be asking the students how they can make a triangular table that fits 24 people.

Reasoning: This way students can deepen their understanding with the area and perimeter of a triangle and know how to split people into 3 different sides of the triangle (PST, 2015).

In the response above the student's reasoning reveals a content knowledge concerns as the problem posed refers to perimeter by asking for space to seat 24 people, yet the PST's reasoning indicates the question is accessing area and not just perimeter, calling into question the PSTs understanding of the definitions of area and perimeter and the relation between the two.

Wording of the question.

Beyond content knowledge concerns another challenge for PSTs in posing purposeful questions was the language chosen. A trend in the responses of both control and experimental groups show that respondents were trying to reach a higher level of thinking in their questions, yet wrote the question in such a format it elicited a yes or no response (DOK 1). See sample below:

Video 1: Are there any recurring patterns or repetitions you see within the different groups of dots that could help you figure out what the beginning point was for the third group? (PST, 2015).

Video 1: Can you create a real-life situation that can fit with these functions? (PST, 2015).

Video 2: James is planning a dinner and has determined that he needs a table with a perimeter that is larger that 50ft^2 in order to accommodate for all his guests. The table he has is 15 ft. in length and 12 ft. in width. Will the perimeter of this table be able to accommodate all of James's guests? (PST, 2015).

In the questions above the first words "Are there", "Can you" and "Will" designate a yes/no response placing the question at a less rigorous level. An addition of the statement "justify your reasoning for" at the beginning of the sentence would have increased the purpose of the question to require higher levels of thinking from the students. Considering that even the experimental after intervention still trended towards yes/no questions as seen in video 2 above, perhaps an intervention including specifically how to avoid yes/no questions should be considered.

Discussion and Implications

To be added:

- Discussion of problem generation and reformulation ability in relation to content knowledge
- Discussion of perception of confidence in relation to content knowledge
- Implications of this work for teacher educators
- Plans for future study

References:

Ball, D. L., Forzani, F. (2009). The work of teaching and the challenge for teacher education. *Journal of Teacher Education, 60*(5), 497–511.

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

Battista, M. (1990). The relationship of mathematics anxiety and mathematical knowledge to the learning of mathematical pedagogy by preservice elementary teachers. School Science and Mathematics, 86, 10-19.

Boling, E. C. (2007). Linking technology, learning, and stories: Implications from research on hypermedia video-cases, *Teaching and Teacher Education*, 23, 189-200.

Borko, H., Jacobs, J., Eitejorg, E., & Pittman, M. (2008). Video as a tool for fostering productive discussions in mathematics professional development, *Teaching and Teacher Education*, 24(2), 417-426.

Bromme, R. and Brophy, J. (1986). Teachers' Cognitive Activities, in B. Christiansen, A. G. Howson and M. Otte (eds.), *Perspectives on Mathematics Education*, Dordrecht, Holland: D. Reidel.

Bursal M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. School Science and Mathematics, 106(4) 173-179.

Cai, J., & Cifarelli, V. V. (2005). Exploring mathematical exploration: How two college students formulated and solved their own mathematical problems. *Focus on Learning Problems in Mathematics, 27*(3), 43–72.

Cai, J., & Hwang, S. (2003). A perspective for examining the link between problem posing and problem solving. In N. A. Pateman, B. J. Dougherty, & J. T. Zilliox (Eds.), *Proceedings of the 2003 Joint Meeting of PME and PMENA* (Vol. 3, pp. 103–110).

English, L. D. (1997). Promoting a problem-posing classroom. *Teaching Children Mathematics, 4*(3), 172–179.

English, L. D. (2003). Problem posing in the elementary curriculum. In F. Lester, & R. Charles (Eds.), Teaching mathematics through problem solving (pp. 187–198). Reston, Virginia: National Council of Teachers of Mathematics.

Ernest P (1988) The attitudes and practices of student teachers of primary school mathematics. In: Proceedings of the 12th annual conference of the international group for the psychology of mathematics education, Veszprem, 20–25 July 1988, vol 1, pp 288–295

Ernest, P. (1991) The Philosophy of Mathematics Education, Falmer Press, London.

Friel, S., Carboni, L. (2000). Using video-based pedagogy in an elementary mathematics methods course. *School Science and Mathematics*, 100(3). 118-127.

Gonzales, N. A. (1994). Problem posing: A neglected component in mathematics courses for prospective elementary and middle school teachers. School Science and Mathematics, 94(2), 78–84.

Gonzales, N. A. (1998). A blueprint for problem posing. *School Science and Mathematics, 98*(8), 448–456.

Graven, M. (2001), Investigating mathematics teacher learning within an in-service community of practice: The centrality of confidence, Educational Studies in Mathematics September 2004, Volume 57, Issue 2, pp 177-21.

Gresham, G. (2010). A Study Exploring Exceptional Education Pre-service Teachers' Mathematics Anxiety,IUMPST: The Journal. Vol 4 (Curriculum), December 2010. [www.k-12prep.math.ttu.edu]

Hadamard, J. W. (1945). *Essay on the psychology of invention in the mathematical field*. Princeton, NJ: Princeton University Press.

Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Kontorovich, I., et al. An exploratory framework for handling the complexity of mathematical problem posing in small groups. Journal of Mathematical Behavior (2012), Volume 31, Issue 1, March 2012, Pages 149–161

Kreide, A., Eubanks-Turner, C., Tomlinson, A. (2015). Preservice teachers' development of questioning skills through Common Core aligned exemplar videotaped math lessons. *Proceedings of the Hawaii University International Conferences,* 13 pages. Retrieved from http://www.huichawaii.org/steam2015p.html

Lampert, M., & Ball, D. (1998). Teaching, multimedia, and mathematics: Investigations of real practice, New York, NY: Teachers College Press.

Leung, S., & Silver, E. A. (1997). The role of task format, mathematics knowledge, and creative thinking on the arithmetic problem posing of prospective elementary school teachers. Mathematics Education Research Journal, 9 (1), 5–24.

Ma, L. (1999). Knowing and teaching elementary mathematics. Mahwah, NJ: Lawrence Erlbaum.

NCTM - National Council of Teachers of Mathematics (2000). Principles and standards for school mathematics. Reston, VA.

Rhine, S., Bryant, J. (2007). Enhancing pre-service teachers' reflective practice with digital video-based dialogue, Reflective Practice, 8(3), 345-358.

Santagata, R., Zannoni, C., & Stigler, J. (2007). The role of lesson analysis in pre-service teacher education: An empirical investigation of teacher learning from a virtual video-based field experience. *Journal of Mathematics Teacher Education*, 10(2), 123–140.

Sherin, M.G. (2004). New perspectives on the role of video in teacher education. In J. Brophy (Ed.), Using video in teacher education (pp. 1-27). New York: Elsevier Science.

Sheirn, M.G., van ES, E.A. (2005). Using Video to Support Teachers' Ability to Notice Classroom Interactions. Jl. Of Technology and Teacher Education, 13(3), 475-491.

Silver, E. A. (1994). On mathematical problem posing, For the Learning of Mathematics, 14(1), 19-28

Silver, E. A., & Cai, J. (1996). An analysis of arithmetic problem posing by middle school students. *Journal for Research in Mathematics Education, 27*(5), 521–539.

Silver, E. A., Mamona-Downs, J., Leung, S., & Kenney, P. A. (1996). Posing mathematical problems: An exploratory study. Journal for Research in Mathematics Education, 27(3), 293–309.

Singer, Florence Mihaela, Nerida F. Ellerton, and Jinfa Cai. (2015) *Mathematical Problem Posing: From Research to Effective Practice*. N.p.: n.p., n.d. Print.

Stipek,D.J., Givvin, K.B.,Salmon, J.S., MacGyvers, V.L. (2001), Teachers' beliefs and practices related to mathematics instruction, Teaching and Teacher Education 17, 213-226.

Thanheiser, E., Browning, C. Edson, A.J., Kastberg, S., Lo, J.J., "Building a Knowledge base: Understanding prospective elementary school teachers' mathematical content knowledge." International Journal for Mathematics Teaching and Learning. July 2013.