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PRE-SERVICE TEACHERS' DEVELOPMENT OF QUESTIONING SKILLS THROUGH COMMON CORE ALIGNED EXEMPLAR VIDEOTAPED MATH LESSONS

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Synopsis:

This study documents the effects of video observation on the development of deep questioning skills of pre-service teachers in a mathematical content course for K-8 pre-service teachers. In particular, we examine the questioning strategies used by pre-service teachers in written responses related to Common Core aligned videotaped math lessons.

Pre-service teachers' development of questioning skills through
Common Core aligned exemplar videotaped math lessons
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Abstract

This study documents the effects of video observation on the development of deep questioning skills of pre-service teachers (PSTs) in a mathematical content course for K-8 pre-service teachers. In particular, we examine the questioning strategies used by pre-service teachers in written responses related to Common Core aligned videotaped math lessons. Data was analyzed to develop multi-tiered general categories and levels of questions used by the PSTs. Through an examination of the trending categories and question levels relational to the videos we offer suggestions for pre-service teacher education courses.

KEY WORDS: mathematics questions, pre-service teacher education, questioning techniques, exemplar modeling

Introduction:

Teachers across the nation are preparing to transition to 21st century standards in math and science with the addition of Common Core Mathematics and Next Generation Science Standards. In these standards students are not required to memorize content, but instead focus is placed on skill acquisition. 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). The idea behind the movement is that content can be accessed at anytime from the Internet, however skills allow students to be successful in an economy where jobs they will be performing have yet to be created. “As a consequence, effective education can no longer be focused on transmission of pieces of information that, once memorized, constitute a stable storehouse of knowledge” (Darling-Hammond, 2008) Teaching 21st century skills requires “meaningful learning” (Brophy, J. & Good, T., 1986), learning that encompasses problem solving, critical thinking and transfer of knowledge skills.

In particular, to be effective mathematics teachers have to structure their teaching practice to build meaningful classroom discussion around problem-solving that leads to students' deeper understanding of mathematics (Cartier, J.L., Smith, M.S., Stein, M.K., & Ross, D., 2013). Based on the NCTM process standards (NCTM, 2000) and the strands of mathematical proficiency specified in the National Research Council's report Adding It Up (2001), the Mathematical Practices (MPs) are “processes math educators at all levels should seek to develop in their students” (NGA, 2010). The MPs are also closely aligned with Polya's steps to problem solving (Polya, 1945) and the Mathematical Habits of Mind (Cuoco et.al., 1996) that describe processes or methods involved in mathematical problem solving and reasoning. Since MP's are procedures that have been linked to gains in mathematical achievement, both researchers and

teachers alike find value in considering ways to better engage students in the MP's and problem solving in the classroom (Marrongelle, K., Sztajn, P., & Smith, M., 2013; Boaler, J., Staples, M., 2008; Schmidt, W., et al., 2011)

To develop these higher-order skills many researchers agree that questioning can be used as a powerful instructional tool (Blumenfeld, P. et al., 1991; Brophy, J. & Good, T., 1986; Legg, A., 1971). Latham (1997) notes that questioning is used not only for students' assessment, but also engages students in higher-order thinking process and stimulate their curiosity. In 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 pre-service teachers are provided with the necessary experience, time and context to use effective questioning techniques before they are involved in the teaching practice. However, Cotton (1988) stated that research shows that pre-service teachers are given inadequate training in developing questioning strategies and, indeed, that some receive no training at all. Also, during their pre-service years exemplar classroom observation time is absent or limited based on individual programs.

In this case study we examined pre-service teachers' ability to pose cognitively rigorous questions related to Common Core aligned video lessons. Specifically, we investigate the following research question: "Can pre-service teachers pose cognitively demanding questions to model or extend the rigor displayed in exemplar common core aligned mathematics videotaped lessons?" This study is contextualized around each pre-service teacher's ability to develop a rigorous question as measured by Hess'(2009) Depth of Knowledge (DOK) rigor matrix which utilizes Webb's (1997) Depth of Knowledge. For this study only the level of the written teacher question was analyzed for DOK level and not the level of student DOK response to the question (Hess, 2009). To answer this question we analyze written responses from pre-service elementary teachers in a mathematical content course for kindergarten through eighth grade. We give the results of the study and identify specific categories and trends in data. We conclude with a discussion and implications for the results.

Methodology

Participants

The study occurred in one class semester from August to December. Participants were 32 pre-service teachers enrolled in a math content course for elementary education majors. The students were comprised of freshmen and sophomores and for most of the students this was their first mathematical content teaching course. Also, most of the pre-service teacher participants had never taken a pedagogy course. The written reflections of the videos were delivered in the form of a class assignments in which the participants had on average 4 weeks to complete. Throughout the semester, each participant completed a total of at most 2 written reflections. The Institutional Review Board (IRB) at Loyola Marymount University approved the study in the summer of 2014 prior to its fall 2014 implementation. Pre-service teacher participants were made aware of the study and those that opted into the study were notified their responses would be kept anonymous. Pre-service teacher participants placed their written responses to the study prompt on a Google form where their only identifier became the timestamp (date and time) when their response was entered.

Procedure

The pre-service teachers were assigned to watch video clips of master teachers teaching lessons on the website: <http://www.teachingchannel.org>. These videos consist of exemplar teachers who emphasize common core math standards and engage students in the mathematical practices. A main goal of teaching channel website is to “video showcase—on the Internet and TV—of inspiring and effective teaching practices in America's schools” (teachingchannel.org, 2015). We chose this site because it is known for displaying exemplar videos in line with best practice education pedagogy and the Common Core. Two specific grade levels were represented due to access of exemplar videos on the Teaching Channel one in grade 1 and one in grade 4, which contained identical use of math practice 2, math practice 3, and depth of knowledge at a level 2; so as to minimize the number of variables present. Here is a brief synopsis of each of the 2 videos:

The first video “Leprechaun Traps: Addition with 100” is an eleven minute video containing a lesson given in a first grade class that emphasizes using multiple strategies to solve addition problems. Video 1 included the Common Core State Standards Mathematical Content (CCSS) (Math 1.NBT.C4) Numbers and Operations in Base Ten: Use place value understanding and properties of operations to add and subtract. The complete content standard is listed “Add within 100, including adding a two-digit number and a one-digit number, and adding a two-digit number and a multiple of 10, using concrete models or drawings and strategies based on place value, properties of operations, and/or the relationship between addition and subtraction; relate the strategy to a written method and explain the reasoning used. Understand that in adding two-digit numbers, one adds tens and tens, ones and ones; and sometimes it is necessary to compose a ten” (2010). Video 1 elicited two mathematical practices (MP), “reason abstractly and quantitatively” MP 2 and “construct viable arguments and critique the reasoning of others” MP 3. The 8 mathematical practices are defined by the Common Core Standards as descriptors of “mathematically proficient students” (2010).

The second video entitled “Multiplying Whole Numbers & Fractions” is a 9 minute video that emphasizes understanding of multiplication as repeated addition in the context of gardening. Specifically, students are posed the following question “If a garden has four corners, how much ribbon will be needed to have a $\frac{2}{3}$ yard ribbon in every corner?” Video 2 included the grade 4 Common Core State Standards Mathematical Content (Math 4.NF.B.4b) Numbers and Operations - Fractions: Build fractions from unit fractions. The complete content standard is listed: “Understand a multiple of $\frac{a}{b}$ as a multiple of $\frac{1}{b}$, and use this understanding to multiply a fraction by a whole number. *For example, use a visual fraction model to express $3 \times \frac{2}{5}$ as $6 \times \frac{1}{5}$, recognizing this product as $\frac{6}{5}$. (In general, $n \times \frac{a}{b} = \frac{n \times a}{b}$.)” (2010). Video 2 is identical to Video 1 in that it elicited two mathematical practices (MP), “reason abstractly and quantitatively” MP 2 and “construct viable arguments and critique the reasoning of others” MP 3.*

For each written reflection participants were assigned both videos described above from the website at two separate times in the semester long course to look at and respond to the video. In this study we examined preservice teacher responses to the prompt below:

Compose a question that the teacher could ask 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 standard(s) the question is aligned with.

To assess the cognitive rigor that each written response would elicit if posed as a question, we utilized Hess’ Cognitive Rigor Matrix which applies Webb’s Depth of Knowledge levels to Bloom’s Cognitive Process Dimensions for a more complete lens of rigor in terms of complexity not difficulty (Hess, 2009). DOK allows us to look at the assessment item/standard to determine the riogr level, however it does not determine the students’ DOK response level. In this framework the context of the item/standard and access to multiple pathways or solutions must be considered, as one does not simply look at what verb was chosen to assign the task (Hess, 2009; Webb, 1997).

Inter-rater reliability was achieved through three independent researchers scoring responses based on the analysis of the following criteria: Initial video DOK, teacher created question DOK level, justification for DOK level of teacher by reviewer, trend(s) present in question, Common Core Mathematical Practices present, question specificity, and content knowledge concerns. To help ensure evaluative validity peer debriefing was utilized by the same three researchers who evaluated the student developed questions. Each reviewer presented their scores of every individual student response in an effort to achieve group consensus on DOK level of the student’s question. Trends, student content knowledge, and mathematical practices in the student created questions were also discussed and themes surfacing in the discussions were coded. Exemplar teaching channel videos were assessed and watched in thirds and three coders rated each third for DOK level. To find the DOK Level for each video, the mode of all three sections of the videos and all three coders were taken. We rated both video lessons assigned to the pre-service teachers as having an overall DOK level 2.

Results

Table 1. Number of Pre-Service Teacher Responses to Demo Videos

Demo Video	Responses n= 62	Percentage %
Video 1	32	51.6
Video 2	30	48.4

* Video 1 grade 1 CCSS Math 1.NBT.C.4 (addition w/in 100)

* Video 2 grade 4 CCSS Math 4.NF.B.4b (multiplying whole numbers and fractions)

Table 1 represents the number of pre-service teacher responses sample size (n= 62) for each of the 2 exemplar videos at an average of about 50.0% for an even number of participant responses. Video 1 represents the grade 1 level content while video 2 represents the grade 4 level content as described above (see procedure). In Table 2 both video 1 and 2 represent Hess’

Cognitive Rigor Matrix Level 2 (DOK 2) defined as the application of skills and concepts (Hess, 2009). A participant response that is the same DOK and level as the videos will be at a level 2 DOK, while a decrease represents a level 1 DOK and an increase represents a level 3 DOK.

Table 2. DOK Levels of Participant Responses vs Demo Video DOK Levels

Participant Response	Video 1 n=32		Video 2 n=30		Video 1 & 2 n=62	
	n	Percent	n	Percent	n	Percent
DOK increase	2	6.3	1	3.3	3	4.8
DOK same	17	53.1	4	13.3	21	33.9
DOK decrease	13	40.6	25	83.4	38	61.3

Table 2 indicates the DOK levels of pre-service teacher questions compared to the exemplar videos. In Video 1 (first grade) 53.1% of participants were able to match the DOK level present, 6.3% increased the DOK, and 40.6 % decreased the DOK level. In Video 2 (fourth grade) 13.3% of participants were able to match the DOK level present, 3.3% increased the DOK, and 83.4% decreased the DOK level. DOK levels and mathematical practices present in Video 1 and 2 were constant. This suggests the variable of grade level standards (first vs. fourth) may play a role in pre-service teachers ability to model rigor, as indicated by the 40.0% decrease in teachers able to achieve the same DOK level in the 4th grade video when compared to the first grade video. Overall in both videos 33.9% of the participants were able to match the DOK level present, 4.8% increased the DOK, and 61.3% decreased the DOK level. The trend with video modeling alone is that only about one-third of pre-service teachers are able to access the same level of DOK and the number decreases with increasing grade levels, suggesting content knowledge may play a role in rigor.

Table 3. Mathematical Practices (MP's) and DOK Trends in Participant Responses

Participant Responses	Video 1 n= 32		Video 2 n= 30	
	n	Percent	n	Percent
MP listed and asked in question				
DOK increase		---		---
DOK same	3	9.4		---
DOK decrease		---		---
MP listed not asked in question				
DOK increase	2	6.3		---

	DOK same	8	25.0	---	
	DOK decrease	4	12.5	7	23.3
Incorrect MP listed for question					
	DOK increase		---		---
	DOK same	1	3.1	1	3.3
	DOK decrease	1	3.1	1	3.3
No MP listed or asked in question					
	DOK increase		---	1	3.3
	DOK same	5	15.6	2	6.7
	DOK decrease	8	25.0	18	60.0

Table 3 illustrates the presence or absence of mathematical practices in pre-service teacher questions and their relation to the level of rigor present. In coding the responses four levels of MP categories came to the forefront:

1. Participants who listed which MP was accessed and the MP was explicit in their question.
2. Participants who listed which MP was accessed but the MP was not explicit in their question.
3. Participants who listed an incorrect MP for their question.
4. Participants who did not list or ask for a MP in their question.

In both videos 3 responses or 4.8% listed and asked for a MP in their question all of whom reached the same DOK level in the first grade Video 1. No increase or decrease in DOK was found to contain a listed and asked MP in the question with the grade four standards in video 2. An example of a MP listed (construct viable arguments and critique the reasoning of others) and asked in a question is as follows:

Enrique argues that $12.4 \times 100 = 12.400$. Maria says he's wrong and the correct answer is 1240. Who is correct and explain why (include the important use of multiplication rules and decimal place values). This question will help students get over the misconception and if they understand why Enrique is wrong, it shows that they are really understanding the concept of multiplying by tens and the importance of moving over the decimal value. This relates to the common core standard that reasons abstractly and it helps them practice the skill of constructing viable arguments and critique the reasoning of others (pre-service teacher 10/21 14:39:54).

In the second category about one third of participants cited the use of a MP that was not asked for in the question. Video 1 with the first grade content had double the number of participants in this category as Video 2 with the fourth grade content; possibly suggesting the citation of a math practice although not explicitly asked in the question was easier to identify in content at a lower grade level. In this category Video 2 was only represented in 23.3% of the participants and was only found to occur with a decrease in DOK level, while Video 1 occurred an overall 43.8% in same, increase, and decreased DOK levels. Below is an example from Video 1 of a listed MP not asked in the question:

I have to go to the store to get buckets for this class which has 28 children in it. How many buckets do I need to buy if I want to put an equal amount of students in every group? This question will help the students deepen their mathematical knowledge because first of all they are applying it to their everyday life, they are seeing how there is more than one way to answer the question, and they are working on word problems. This aligns with:

Make sense of problems and persevere in solving them, reason abstractly and quantitatively construct viable arguments and critique the reasoning of others, model with mathematics, and look for and make use of structure. (pre-service teacher 10/16 13:24:28)

While five MP's are listed in the example above the student is only asked to list "how many buckets" for an equal number of students, not specifically asking for modeling, arguments, critiques, structure, reasoning, or approach to the problem found in the MP's.

The third category includes a MP that was identified incorrectly for the question the participant designed. This occurred in 4 cases or 6.5% which equally accounted for both the same and decreased DOK levels for each Video. An example of an incorrect MP listed is below in Video 2:

What is the relationship between addition and multiplication in this lesson? If the students are able to recognize that repeated addition is actually a form of multiplication (by looking at the pictures and diagrams) I think is the most important takeaway from this lesson. Like the teacher mentioned, once students realized this, a major shift occurred in terms of the student's thinking. This question also relates to how we only multiply the numerator, because the denominator is the "whole" and therefore needs to stay the same. The standards this lesson addresses are :Math.4.NF.B.4b, Math.Practice.MP2, Math.Practice.MP3. (pre-service teacher 11/18 10:38:29)

The participant question above asks for the "relationship between addition and multiplication" which does not align with the stated use of MP 3 of construct viable arguments and critique the reasoning of others.

The final category of no MP listed or asked in the question represents 54.8% of the total participants in both videos half of which were respondents from Video 2. A sample from Video 2 is provided below:

Kelsey made $\frac{2}{3}$ batch of chocolate chip cookies. If she ate $\frac{3}{4}$ of it before bed, how much of the batch did Kelly eat? This question would help expand the student's knowledge of the subject because the lesson taught in the video is essentially multiplying fractions. Once the students in the video master the questions posed by the teacher, they will be able to apply what they learned to questions like the one above. Common Core Standard addressed: CCSS.MATH.CONTENT.4.NF.B.4. (pre-service teacher 11/20 00:45:20)

Table 4. Participant Response Trends in Same DOK Level Questions

Trend	Video 1 n= 17	Video 2 n= 4	Both Videos n= 21
	n Percent	n Percent	n Percent

Teacher provides another form of the question which directly models the video	8	47.1	2	50.0	10	47.6
Teacher provides a different type of question compared to the video	9	52.9	2	50.0	11	52.4
Question extends the content to include another common core cluster	3	17.6	0	0.0	3	14.3
Question was not clear for task	4	23.5	2	50.0	6	28.6
Question not grade level appropriate	2	11.8	0	0.0	2	9.5
Question asks “how” or “why” or “yes/no” without justification using student evidence.	12	70.6	3	75.0	15	71.4

Table 4 indicates six main categories of responses found in participant questions in which the DOK level of the video was maintained in the teacher question. Note participant responses in most cases qualified in more than one category. Video 1 first grade responses indicate a four times higher sample size (n=17) than Video 2 (n=4) grade four responses which could indicate rigor is harder to maintain in higher grade level content. In Video 1 70.6% of the questions and Video 2 75.0% of the questions asked how, why, or yes/no answers thereby reaching a DOK level of 2. In many of these how or why questions participants could have raised the DOK level by asking students to justify their reasoning from evidence provided by a model or equation. Another trend in both videos achieving the same DOK was that approximately half of the questions asked the same form of the question modeled in the video, while the other half were unique. Only in Video 1 (17.6%) did questions extended to include another cluster of the common core. Also in Video 1 there were two respondents whose question exceeded the first grade content standards. Video 1 trends showed 50.0% of the questions were not clear for the task. One example of an unclear response from Video 2 is as follows:

Brenda is going to have 36 people at her birthday party. Her best friend Michael is in charge of buying party hats from Party City. Party City sells party hats in packs of 2, 3, 4, 5, and 6. If Michael needs to buy 36 hats, how many different ways can he purchase the hats if all packs have the same amount in them? Come up with three different ways. (pre-service teacher 10/20 19:13:45).

In the question above “if all packs have the same amount in them” could limit and confuse a first grader in their response to the question.

Table 5. Participant Response Trends in Decreased DOK Level Questions

Trend	Video 1 n= 13		Video 2 n= 25		Video 1 & 2 n= 38	
	n	Percent	n	Percent	n	Percent
Question extends the content to include another 5.3 common core cluster at a DOK 1 level	0	0.0	2	8.0	2	
Question was not clear for standard	4	30.8	3	12.0	7	18.4
Question had content knowledge concerns	0	0.0	2	8.0	2	5.3

** Note all questions above are at a DOK 1 level of reproduction and recall*

Table 5 represents trends in participant responses where the DOK level of the question formulated was lower when compared to the model video. Three main areas stood out such as questions extending into another content cluster, not clear for task, or had content knowledge concerns. Content knowledge concerns were only seen in the fourth grade video suggesting the increased grade level could have higher level of content issues. Questions that were not ambiguous at 30.8% were mostly found in the first grade video. A sample at the decreased DOK or level 1 of an unclear question is “why is our daily math routine so important to do special assignments such as “Leprechaun Traps”. (pre-service teacher 10/21 17:21:47) In the question it is unclear what the teacher means by daily routine and special assignments, as only one video clip of the exemplar teacher’s classroom was modeled.

Discussion:

In this study the use of Common Core aligned exemplar videotaped math lessons were investigated as a means to support pre-service teachers' development of questioning skills. As Common Core Mathematics Standards move away from rote memorization towards application of concepts (DOK 2+) it becomes essential for teachers to include the mathematical practices (MPs) in their questioning to assess student learning at higher levels of rigor (Clements, D. and Battista, M., 2009). However, trends in the data indicate a lack of awareness or understanding regarding the MPs. For example, pre-service teacher instructions for all of the sample responses were as follows, “Using a thoughtful and detailed response compose a question that the teacher could ask 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 standard(s) the question is aligned with.” The question did not specifically ask for mathematical practices, but did ask for the common core mathematical standard/s, suggesting that pre-service teachers do not associate the mathematical practices as components of the common core mathematical standards. Over half of the

pre-service teacher responses did not contain a mathematical practice, indicating a possible disconnect between pre-service teachers ideas of the standards and their relationship to the mathematical practices. It may be important to note that addition of the MPs is one main difference between past CA Standards and current Common Core Mathematical Standards.

Also seen in the data was the lack of pre-service teachers requesting student justification of a solution to a problem through evidence such as equations, tables, graphs, pictures, etc. This idea of justification represents another shift not found in past CA Content Standards, but essential in current Common Core Mathematical Standards. Pre-service teachers trended towards questioning without justification of a solution and instead asked “why”, “how”, or “yes”/“no” questions that could be answered in one word, thus plateauing their questions at a DOK 1/2 level. This could indicate a misconception of the use of “how” or “why” being equated with the same student response as “justify”. Also, due to the age of the participating pre-service teachers, given that Common Core Math Standards required implementation in 2014 are less likely to have been taught as math students how to themselves justify their answers and may never have learned the skill based math practices.

Overall, only one-third of pre-service teachers were able to reach the DOK 2 level presented in the videos, while less than 5% were able to reach a DOK 3 level. However, preservice teachers were specifically asked to “compose a question that the teacher could ask to help expand or deepen the students mathematical knowledge” possibly indicating that in responding to the prompt a level 3 DOK problem should be the norm. Thus, suggesting a lack of how to increase the rigor of a mathematical problem. It is interesting to note that in the one-third of respondents who reached the same DOK level as the video, four times less responses were from video 2 as opposed to video 1. Possibility indicating the increase of rigor was easier to achieve in video 1 grade 1 standards as opposed to video 2 grade 4 standards. This could call into question the comfort level of the pre-service teachers with their own content knowledge. The idea of teacher content knowledge as a factor in problem development is in line with research from Smilansky who analyzed empirical data and concluded, “the problem solving ability could not be a sufficient condition but a necessary condition for problem posing ability” (1984).

Conclusion

The preliminary research presented in this case study indicates possible directions for future research in the area of pre-service teacher education in the development of questioning skills through exemplar mathematics teaching videos. Video modeling was chosen due to its accessible nature. Pre-service teachers who spend a majority of their day themselves in classes, are generally unable to attend teacher classroom observations. Also, videos eliminates the variable of teacher availability and teaching ability in the classroom. Finally, it allows for all pre-service teachers in the classroom to come from the same prior video experience to engage in collaboration with their classmates around a common experience. This common reference point allows teachers to use the videos as a scaffold as they move into real classroom environments. Therefore, utilizing exemplar videos in future teacher modeling research would be suggested as a means to control teaching and timing variables.

Other consideration and guiding questions for future research include:

1. The creation of a lesson plan to access a particular standard.
2. Is there a link between DOK level of pre-service teacher responses and a constructivist or traditional teaching pedagogy?
3. Do the pre-service teachers have math anxiety from their own education calling to question their confidence with the higher grade level standards?
4. Reviewing the pre-service teachers understanding of “how” versus “justify”.
5. Testing pre-service teachers content knowledge to see if it has an effect on the DOK level questions created.
6. Study teacher pre-service models that include 2 semesters of math content education based in the standards.
7. Comparison of a year 1 teacher versus a pre-service teacher to see if questioning ability improves once in the classroom.
8. Direct pre-service teacher training in DOK as part of the course content. Compare trained and untrained groups to see which group is best able to maintain or increase rigor in a mathematical standard.

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