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Impacting Secondary Mathematics Preservice Teachers' Vision of Role of Teacher[1]

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Our Context

For the past three years, our research team has been conducting investigations in the context of a secondary mathematics methods course. In that course, we engage preservice teachers (PSTs) in Cycles of Enactment and Investigation (CEIs), which we have adapted from the work of Lampert and her colleagues (Lampert, et al., 2013). Our modified CEIs are represented in Figure 1.

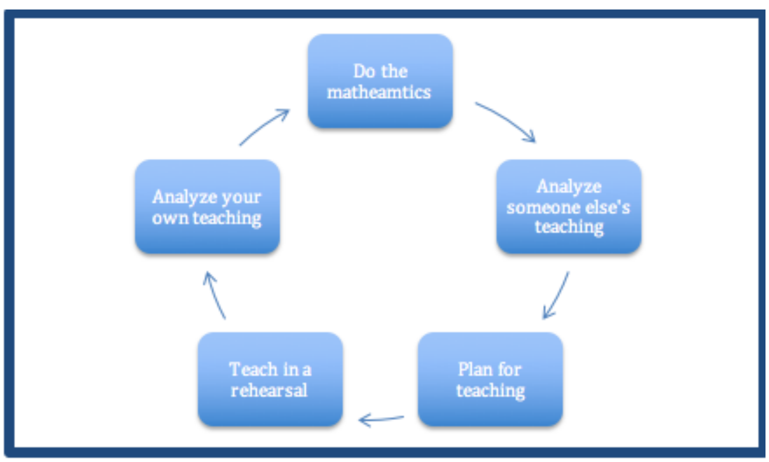

Figure 1. Our modified CEI

In a typical semester, we are able to engage in 3-4 CEIs. All rehearsals are conducted in the during the methods course, with other PSTs or doctoral student assistants playing the role of the "students" and the course instructor playing the role of coach. While the mathematical content of

[1] A revised version of this paper, to contain a more typical research-paper introduction and literature review section as well as expanded methods, findings, discussion, and conclusions sections, will be available to attendees during the conference session.

each CEI changes from time to time, what remains constant is the decomposition of practice that we focus on in all of the CEIs. Employing a pedagogies of practice approach (Grossman, Compton, Igra, Shahan, and Williamson, 2009) to teacher education, our focus decomposition of practice, and overarching pedagogical goal for all CEIs, is the use of assessing questions (Smith, Bill, & Hughes, 2008) to elicit how “students” are thinking about a mathematical problem and then asking advancing questions (Smith, Bill, & Hughes, 2008) and make appropriate use of telling (Lobato, Clarke, & Ellis, 2005) to move students towards the mathematical goal of the task.

In another study conducted in this context, Freeburn (2016) examined the knowledge that the PSTs constructed during the semester about assessing/advancing questions and appropriate telling and the impact of particular course activities on that knowledge. Freeburn’s study provided empirical support for the efficacy of using a pedagogy of practice approach (Grossman, Compton, Igra, Shahan, and Williamson, 2009) for PSTs learning about this particular decomposition of practice. We were heartened by Freeburn’s research findings – the PSTs learned what we had intended for them to learn from the course - the *intended* outcomes for the course.

As a research group, one of the activities we engaged in was a read through of data sources. It was during this read through that we noticed something else, and potentially interesting, about the PSTs over the course of the semester. They seemed to be *talking* (verbally and/or in writing) differently about learning and teaching mathematics over time. We wondered what was happening – was there really a difference in the ways that the PSTs were thinking about teaching and learning mathematics at the end of the semester as compared to the beginning of the semester? Was there evidence of this *unintended* outcome that could be documented through a more systematic investigation of the data? Our informal examination of the data led us to the literature to find a theoretical/analytic framework that would allow us to empirically study changes in their *talk* over time. Munter's (2014) work on *Visions of High Quality Mathematics Instruction* caught our interest and we began a systematic coding of the data (see methods section) using his framework.

This paper focuses on this investigation. Specifically, we address the following research question: How did secondary PSTs' visions of "role of teacher" change as an unintended outcome of a mathematics methods course in which they experienced sustained engagement in instructional activities that focused on posing purposeful questions and eliciting and using evidence of student thinking (NCTM, 2014)?

Theoretical and Analytic Framework

Munter (2014) provides a research-informed rubric "for the purposes of characterizing the visions of high-quality mathematics instruction [VHQMI] of teachers, principals, mathematics coaches, and district leaders and tracking changes in those visions over time" (p. 584). The VHQMI rubric has three interrelated dimensions: Role of Teacher, Classroom Discourse, and Mathematical Tasks. As the "role of teacher" dimension is pertinent to this study, we further describe that dimension here.

The VHQMI "role of teacher" dimension contains five levels of sophistication, from 0 (low) to 4 (high): (Level 0) teacher as "motivator"; (Level 1) teacher as "deliverer of knowledge"; (Level 2) teacher as "monitor"; (Level 3) teacher as "facilitator"; and (Level 4) teacher as "more knowledgeable other." Within each level, consideration is given to three potential ways of characterizing a teacher's role: influencing classroom discourse; attribution of mathematical authority; and conception of typical activity structure. Use of this rubric to analyze data allows researchers to assess an individual teacher's level of sophistication in terms of his/her vision of role of teacher.

Methods

Data Sources

The data analyzed for this study are a subset of a data corpus collected in one section (n=17) of a secondary mathematics methods course offered at a large, research-intensive university. We analyzed data from five sources collected in first two weeks of the semester (Interview 1, Reading Journal 1, Reading Journal 2, audio-recording of whole group discussion in class 4) and from three data sources from the last two weeks (Final Paper, Interview 3, and audio-recordings of small group Studio-Code analysis sessions). See Table 1 for details about data sources.

Table 1: Data Sources

Data Source (n=17 PSTs)	Description	Time of Semester
Interview 1	Asked PSTs questions about: 1) prior experiences in secondary math classes; and 2) views about roles of teacher and students in secondary math classes.	Beginning (first 2 weeks)
Reading Journal 1	Read: *Adding It Up: Helping Children Learn Mathematics*, Chapter 4: "The Strands of Mathematical Proficiency" pages 115-135. Respond to writing prompts.	Beginning
Reading Journal 2	Read: 1) *Principles and Standards for School Mathematics* (PSSM); 2) Chapter 1: "A Vision for School Mathematics" Chapter 1 (pages 3-7) from *Focus in High School Mathematics*: *Reasoning and Sense Making*: and 3) "Developing Understanding through Problem Solving" by Hiebert and Wearne. Respond to writing prompts.	Beginning
Audio-recording of Class 4 Whole Group Discussion	Small groups of students shared key points from readings from RJ1 and RJ2 so that they could identify a set of "big messages" from early readings and class discussions. After the small group discussion, the entire class discussed the big messages identified by the small groups.	Beginning
Final Paper	PSTs analyzed and reflected on a small-group problem-solving session that they had led with 1-2 high school	End

	students. The problem-solving session was recorded and PSTs used StudioCode to analyze the session across three types of teacher talk: asking assessing questions; asking advancing questions; judicious telling (primary pedagogical focus of the methods course)	(final 2 weeks)
Audio-Recording of Class 26 Small Group StudioCode Analysis Session	Groups of 3-4 PSTs analyzed each PSTs audio recording of a peer teaching episode across three types of teacher talk: asking assessing questions; asking advancing questions; judicious telling (primary pedagogical focus of the methods course)	End
Interview 3	Asked PSTs questions about: 1) impact of specific course activities on their learning; 2) questioning and question types, including instructional purposes for different types of questions.	End

Data Analysis

Using the VHQMI "role of teacher" rubric, we coded PSTs' "instances" (defined as a "complete thought") from each data source. After reducing the data by coding for "role of teacher," we coded each instance for Level (0-4) and ways of characterizing teacher's role. Our analysis led to two kinds of findings: a quantitative frequency count of the number of instances falling into each Level at the beginning and end of the semester and a qualitative description of the nature of the instances.

Findings

Data analysis indicates that the majority of PSTs' comments from the **beginning of the course** were coded as **low-level** (see Table 2, column 2) and the majority of comments from **end-of-semester** data were coded as **high-level** (see Table 2, column 3).

Table 2. Percentages of low-level instances at beginning of semester and high level instances at the end of the semester

Role of Teacher Rubric	Percentage of Instances Labeled Low-Level (Levels 0,	Percentage of Instances Labeled High-Level (Levels 3 and 4) at end of semester

	1, and 2) at beginning of semester	
Influencing Classroom Discourse	74.49%	53.52%
Attribution of Authority	67.8%	82.91%
Conception of Typical Activity Structure	86.99%	76.09%

It is evident from these findings that, as a group, the PSTs became more sophisticated over time when describing the role of teacher. Our qualitative examination of the data provided us with a more descriptive account of the changes we saw. In the following sub-sections, we present representative excerpts from our data set in the categories of attribution of authority, influencing classroom discourse, and conception of typical activity structure.

Influencing classroom discourse. At the beginning of the semester, a high percentage of the PSMTs' statements coded Role of Teacher and categorized Influencing Classroom Discourse were low-level (74.49%). Munter describes the low-level Influencing Classroom Discourse dimension as,

- Suggests the teacher should promote student-student discussion in group work (Level 2)
- Focuses exclusively on teacher-to-student discourse. Considers quality of teacher's explanations in terms of clarity and mathematical correctness (Level 1).

Many of the PSMTs' statements that we coded as low-level in this category focused on the quality of teacher's explanations of mathematical ideas and the teacher's explanations to students' questions in the classroom. For example, PT7 described being dissatisfied with her high school teacher who would answer her "Why?" questions with short, dismissive answers:

> I vowed when I became a teacher I would not answer any question in that manner because that is exactly what happened to me frequently in this class. Obviously, it was a higher math class and many students grasped the concepts much more quickly than I did so I became very frustrated when I wasn't given enough time to gain understanding before someone shouted out the answer and we would move on. I constantly stopped her to ask, 'Why is that the case?' and she would always answer, 'That's just the way it is' (Reading Journal 1, PT7).

While this statement isn't directly about classroom discourse, it indicates that PT7's vision of instruction involves clear teacher explanations that support students' learning of a concept. In another example, PT11 emphasized the importance of teacher explanations in justifying the importance and relevance of mathematical ideas:

> This shows why we must give them an excellent understanding of mathematics because a deep understanding will help them to further their careers even if the ideas were never specifically taught in the classroom. I also feel that this could be a way of explaining to students why they need to learn concepts that they feel will never be useful to them. If we can explain that the workforce is constantly changing and that new jobs are constantly being created it could be a stepping-stone to explaining why something may be useful later in life.

PT11 emphasizes the teacher's role of "explaining to students," which is an indicator of teacher to student discourse included in Munter's rubric as a descriptor of low-level statements.

At the end of the semester, a majority of the PSMTs' statements coded Role of Teacher and categorized Influencing Classroom Discourse were coded as high-level (53.52%). Munter describes the high-level Influencing Classroom Discourse dimension as,

- Suggests that the teacher should purposefully intervene in classroom discussions to elicit & scaffold students' ideas, create a shared context, and maintain continuity over time …
- Describes the teacher facilitating student-to-student talk, but primarily in terms of students taking turns sharing their solutions; hesitates to "tell" too much for rear of interrupting the "discovery" process.

The PSMTs' high-level coded statements in this category addressed several aspects of these descriptors: teacher's role in facilitating student-to-student discourse, not telling too much, and teacher's role in discussions to elicit and scaffold students' ideas. As representative of the group, two examples from PT7 are included here. In the first example, PT7 emphasized the teacher's role in eliciting students' thinking in order to support the teacher's subsequent instruction:

> These types of questions [assessing] are very important when it comes to having them discover patterns on their own and eventually understand the topic. Through an effective series of assessing questions, you, as the teacher, can figure out what the student already knows, what they currently understand about mathematics or the problem at hand, and what their pattern of thinking may be in order to lead them in a direction that makes the most sense to them (Final Paper, PT7).

PT7's statements about the use of assessing questions to "figure out what the student already knows" and "in order to lead them in a direction that makes the most sense to them" aligns with Munter's descriptor about the teacher's role in a classroom discussion to elicit and scaffold students' thinking. In another example, PT7 cautions against the use of inappropriate telling:

> Telling statements are also important but should be used wisely. You, as the teacher, do not want to give away too much information that you hinder the development of the student. A telling statement in which you flat out tell them the equation to use and expect

> them to memorize it would be ineffective and the exact opposite of what we have learned all semester. An effective telling statement would be a statement that inserts terminology or to establish context (Final Paper, PT7).

PT7's statements about how telling may be effective and ineffective align with Munter's descriptor in which he addresses not telling too much.

Attribution of authority. According to Munter (2014), low-level comments about attribution of authority:

- Suggest a view of teacher as an "adjudicator of correctness." Students may participate in "teaching" but only as mediators of the teacher's instruction, adding clarification, etc. If students are pursuing an unfruitful path of inquiry or an inaccurate line of reasoning, the teacher stops them and sets them on a "better" path. (p. 628)
- Suggest that the responsibility for determining the validity of ideas resides with the teacher or is ascribed to the textbook. (p. 629)

At the beginning of the semester, the majority of the PSTs' comments included descriptions of teachers explaining, showing, presenting, or transmitting the mathematical ideas to the students. For example, PST2 stated, "I can't wait for the day that this questions comes up, 'When are we going to use this?' I'm going to be more than ready [to tell them]. I think that's our role as teachers, to not just present the information, but present it in a way that they stay attentive" (Interview 1). Similarly, PT13 said,

> I definitely think it is important to explain topics in a way that somebody who doesn't know anything about the topic can understand. Because, clearly, I understand the topic, but the hardest part is putting it into words so that someone who is an amateur can understand (Interview 1).

According to Munter (2014), high-level comments about attribution of authority

- Suggest that the teacher should support students in sharing in authority, problematizing content, and ensuring that the responsibility for determining the validity of ideas resides with the classroom community (p. 626).
- Support a "no-tell policy": Stresses that students should figure things out for themselves and play a role in teaching. Suggests that if students are pursuing an unfruitful path of inquiry or an inaccurate line of reasoning, the teacher should pose a question to help them find their mistake, but the reason for doing so focuses more on not telling than helping students develop mathematical authority (p. 627).

At the end of the semester, many of the PSTs' comments aligned with Munter's descriptors addressing "problematizing content" and were about asking questions when students pursued "unfruitful paths of inquiry." For example, PST14 wrote,

> I never thought of purposely making mathematics more difficult than it might already seem to students, but it is that small struggle that really allows students to explore and deepen their understanding, and maybe even motivate a liking toward mathematics. By doing this, students are provided a good learning experience because it helps push them to think for themselves and it ultimately will strengthen their mathematical proficiency because they won't get answers handed to them and won't be pre-taught mathematics that shouldn't be. (Final Paper)

In another example, PST12 wrote,

> One characteristic of a good learning experience is when a student can discover mathematical concepts on their own by working on a problem that they can struggle with ... Discovery and problem solving helps student see that there is more than one way to

> solve a problem and through discussion with classmates they can choose which procedure makes the most sense or is the easiest to understand….Another characteristic of a good learning experience is when a teacher can facilitate a lesson where students can struggle with a problem and discus with classmate in order to discover a variety of mathematical ideas, without the teacher giving all of the answers away right away. Teachers need to find a balance between stepping back to let students solve a difficult problem and helping students at just the right time. (Final Paper)

Conception of typical activity structure. At the beginning of the semester, a high percentage of the PSTs' statements coded Role of Teacher and categorized Conception of Typical Activity were low-level (86.99%). Munter describes the low-level dimension as,

- Promotes a two phase, "acquisition and application" lesson (Stigler & Hievert, 1999), in which a) the teacher demonstrates or leads a discussion on how to solve a type of problem, and then b) students are expected to work together (or 'teach each other') to use what has just been demonstrated to solve similar problems, while the teacher circulates throughout the classroom, providing assistance when needed
- Promotes efficiently structured lessons (in terms of coverage) in which the teacher directly teaches how to solve problems. Periods might include time for practice while teacher checks students' work and answers questions … Description suggests no qualms with exclusive lecture format.

Many of the PSMTs' coded statements at the beginning of the semester aligned with both the teacher directly teaching how to solve problems and the two phase, acquisition and application lesson. For example, PT2 wrote,

> Throughout the year, he would put a problem on the board at the beginning of class, and said "you will be able to solve this by the end of class". He would then proceed to show us the theory behind the problem and explain what it meant and what we were doing in the problem. Then by the end of class, we could solve and explain what we were doing. This is one method that I may end up using in my class someday (Reading Journal 2).

PT2's statements are about his experienced mathematics instruction, but the final sentence in the passage indicates that this experienced mathematics instruction is a part of his vision of mathematics instruction. PT2's description of instruction in the passage addresses the teacher as transmitting both the problem and theory behind the problem, then the students would use this to solve the problem. This description of instruction aligns with aspects of both of Munter's low-level descriptors – acquisition and application as well as the teacher directly explaining the ideas behind a problem.

In another example, PT 14 wrote,

> Because it might take a few minutes of explaining it to them for them to get it. So, I definitely think there should be a good question and answer period … I definitely think it is important to explain topics in a way that somebody who doesn't know anything about the topic can understand. Because, clearly, I understand the topic, but the hardest part is putting it into words so that someone who is an amateur can understand (Interview 1).

At the end of the semester, a high percentage of the PSTs' statements coded Role of Teacher and categorized Conception of Typical Activity were high-level (76.09%). Munter describes the high-level dimension as,

- Promotes a 'launch-explore-summarize' lesson (Lappan et al., 1998), in which a) the teacher poses a problem and ensures that all students understand the context and expectations … b) students develop strategies and solutions … c) through reflection and sharing, the teacher and students work together to explicate the mathematical concepts underlying the lesson's problem …

- Promotes a 'launch-explore-summarize' lesson (Lappan et al., 1998), in which a) the teacher poses a problem and possibly completes the first step or two with the class or demonstrates how to solve similar problems, b) students work (likely in groups) to complete the task(s), and c) students take turns sharing their solutions and strategies and/or the teacher clarifies the primary mathematical concept of the day …

The launch-explore-summarize lesson structure was a focus in the methods course and the PSTs' were expected to use the structure in planning and enacting lessons. Further, a question at the end of the semester asked the PSMTs how they would coordinate different questions in teaching a lesson using the L-E-S structure. One example of a response to this interviewing prompt was PT7. PT7 explains the way in which she would use the 9 Question Types (Boaler & Humphreys, 2005) in teaching the staircase problem (pattern generalization problem that had been done on the first day of the methods course). She would launch the activity with assessing questions "gathering information" to determine if students understand "what's going on." She gives examples of "simple questions" that involve the students calculating. Then, she would use "extending thinking" because students will "start to find patterns." If students become stuck, she would ask "orienting and focusing" so that the teacher can "guide" the students to finding the pattern USING what the student is telling the teacher. If students are "starting to get" she would use "exploring mathematical relationships." Towards the end of the lesson, she would use "probing" in order to "have them explain why they got what they got and why it makes sense." The lesson would conclude with generating discussion in order "to see what other students got."

In another example from the final interview, PT9 explained an analogy he created for types of teacher talk. His analogy conveys his vision of specific teacher actions that typically occur in classroom instruction. PT9 talks about his "car trip" analogy for assessing and advancing questions. Assessing questions "What did you?" and "Why did you do it?" are questions that get the students off the road and to a rest stop where they may reflect. Advancing questions are questions that get students "back on the road." Since students are going "to need to know where to go" teacher's advancing questions "point students in that direction so that they may explore some more." He gives an example scenario in which an advancing question was used with a student who made a mistake. The student made a mistake in calculating the area of a square and PT9 suggests an advancing question that gets the student to recognize s/he made the error. The advancing pushes the student in "a new direction." He emphasizes that while assessing questions are necessary, overusing these questions cause students to "keep getting off the highway" and not make progress towards a goal. Hence, it is necessary to use advancing questions to focus students on the mathematical goal and support them in making progress in reaching the mathematical goal. He emphasized that the role of the teacher is to create good advancing questions that focus on the students' thinking.

Educational Importance of Research

In a different study associated with our project, we examined the knowledge that the PSTs constructed during the semester about assessing/advancing questions and judicious telling and the impact of particular course activities on that knowledge. Given that the focus of the course was on enhancing their capacities to ask purposeful questions as well as elicit and use evidence of student thinking (NCTM, 2014), an increase in knowledge about these concepts was to be expected, and we think of the findings of that study *intended outcomes* of course participation. What the study reported here indicates is that a focus on these specific teaching practices in a secondary mathematics methods course also supported the *unintended outcome* of an increase of sophistication in PSTs' VHQMI, findings that serve to bolster the field's focus on these teaching practices. Researchers have documented inservice teachers' VHQMI (Munter, 2014), the impact of those visions on the quality of mathematics instruction (Munter, 2015; Willheim, 2014), and as a tool to examine the views of inservice teachers in two working groups focused on examining student data (Horn, Kane, and Wilson, 2015). This research study extends this work by showing that the VHQMI rubrics serve as a useful research tool to document change over time in PSTs' visions of the role of teacher. Existing published research about VHQMI has been conducted in inservice mathematics teacher education contexts; this study is among the first that utilize VHQMI to study teacher learning in a preservice mathematics teacher context.

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