The Development of Critical Teaching Skills for Preservice Secondary Mathematics Teachers Through Video Case Study Analysis

Helene S. Leonard
Montclair State University

Youngjun Kim
Montclair State University

Su San Lim
Montclair State University

Victoria D. Bonaccorso
Montclair State University

Joseph DiNapoli
Montclair State University

Eileen Murray
Math for America

Using social learning theory with the central concept of a community of practice, we situate this work within a secondary mathematics methods course to unpack preservice secondary mathematics teachers (PSMTs) development through the use of video case studies. We analyzed six sessions of the course in which PSMTs engaged in discussions about video segments of mathematics teaching rooted in the Teaching for Robust Understanding (TRU) framework for high-quality instruction. Analysis of this data showed opportunities for PSMTs to develop critical skills for teaching (Hiebert et al., 2007). Our contribution includes the addition of a new skill to Hiebert's framework, Understanding the Mathematics, as an important component of PSMT learning that may precede the original four skills. Future research should focus on connections between PSMTs' evolving mathematical understandings and analysis of video to better understand the impact of their content knowledge on developing the critical skills for teaching.

Keywords: Preservice Secondary Mathematics Teachers, Video Case Studies, Mathematics Methods Course

Introduction

Hiebert and colleagues (2007) suggested four teaching skills that preservice teachers should develop within a teacher education program: (1) specifying the learning goals for the instructional episode; (2) conducting empirical observations of teaching and learning; (3) constructing hypotheses about the effects of teaching on students' learning; and (4) using analysis to propose improvements in teaching. These skills were centered on the notion that the goal of teaching is to support student learning, and therefore, to acquire these skills, preservice teachers needed learning experiences embedded in actual classroom settings (Hiebert et al., 2007). Teacher education programs have provided preservice teachers with experiences in the form of supervised clinical teaching experiences, or practical teaching courses (practicums). However, these experiences are varied depending on individual supervising teachers whose practices might not be aligned with best practices and theories discussed in university methods courses (Cavanagh & Prescott, 2007). Based on these inconsistencies, preservice teachers might rely on their own experiences as students (Feiman-Nemser & Buchmann, 1985). Thus, there is concern that preservice teachers might not have the opportunity to build the critical skills needed to become effective teachers (U.S. Department of Education & Office of Postsecondary Education, 2013).

To build the critical skills for teaching, Hiebert and colleagues (2007) advocated for providing opportunities for preservice teachers to learn to teach from teaching not only within classrooms, but before entering a classroom. Methods courses can provide preservice teachers with such learning experiences where they develop the skills needed for field-based teaching

through analyzing teaching in terms of student learning. One powerful type of learning experience that has been shown to provide preservice teachers a way to view teaching and learning in a classroom setting is the use of video case study (Star & Strickland, 2008). In a methods course, guided discussions and analyses of video-recorded classroom teaching can help preservice teachers focus on important aspects of a lesson, which can provide opportunities for preservice teachers to develop and understand their teaching skills in real contexts (Star et al., 2011). Moreover, new research calls for video case study analysis need to be rooted in a framework for teaching (e.g., Bonaccorso, 2020). In our work, we partnered video case study analysis with the Teaching for Robust Understanding (TRU) framework, which has allowed us to investigate how preservice secondary mathematics teachers (PSMTs) attend to and develop teaching skills necessary to learn how to teach from studying teaching (Hiebert et al., 2007). In particular, this study seeks to answer the following research question: *In what ways does video case study analysis rooted in a teaching framework provide PSMT opportunities to develop the critical skills of teaching?*

Conceptual Framework

Communities of Practice

To understand PSMTs' learning, we adopted a community of practice (CoP) model for our conceptual framework. A CoP is defined as a group of people "who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p. 4). A methods class consists of preservice teachers and the instructor(s) working together to deepen knowledge of teaching and learning during regular course meeting times across a semester. In our study, PSMTs and the methods instructors analyzed video case studies of mathematics teaching in order to foster sustained teacher learning about high-quality instruction using the TRU framework. Therefore, in the context of this study, the methods course acted as a CoP because the group tackled a set of problems around the nature of high-quality instruction and deepened their knowledge regarding the skills needed for successful implementation.

Video Case Studies in Preservice Teacher Education

Researchers have found that video analysis has the potential to focus preservice teachers' attention on particular aspects of teaching and learning. PSMTs typically have difficulties in attending to issues of mathematics teaching and learning when they begin teacher training (e.g., Star & Strickland, 2008). Research has shown that analyzing classroom videos provides preservice teachers a chance to broaden their perspectives regarding what to observe, and direct preservice teachers' attention to critical aspects of mathematics teaching and learning. In particular, Martinez et al. (2015) found preservice teachers' ability to anticipate student mathematical thinking could be enhanced by partnering video watching with a research-based framework. Other researchers (Santagata & Angelici, 2010; Santagata et al., 2007) placed particular emphasis on the use of an observation framework as a lens for analyzing a videotaped lesson. Findings from this research suggested that an observation framework designed to guide teachers' analyses of classroom videos has a positive impact on improving preservice teachers' ability to attend to important elements of the teaching and learning of mathematics. Therefore, PSMTs in our study analyzed video case studies with a specific lens to better understand the teaching of mathematics.

Teaching for robust understanding (TRU). We used video case studies rooted in the TRU framework to help PSMTs align their understanding of mathematics teaching and learning to dimensions of high-quality instruction that support deep mathematical learning opportunities for students. The TRU framework is categorized by five interrelated dimensions of high-quality mathematics instruction: (1) the mathematical content; (2) cognitive demand; (3) equitable access to content; (4) agency, ownership, and identity; and (5) formative assessment (Schoenfeld, 2017). In this study, the purpose of using video case studies rooted in the TRU framework was to focus PSMTs' discussions on particular aspects of powerful mathematics classrooms and provide them with a common language to examine the teaching and learning of mathematics.

Methods

Context

The participants of the study include 12 PSMTs enrolled in two separate sections of an undergraduate mathematics methods course that met on campus. This course is the second of two required methods courses that PSMTs took prior to their practicum experience. Each of the six 75-minute sessions studied was facilitated by the course instructor. On two occasions, an additional instructor familiar with the teaching materials and framework provided support.

Over the course of each semester, the instructor scheduled three sessions for video case study analysis. For these course meetings, PSMTs engaged with the mathematics in the lesson, viewed a video clip from a real classroom setting, and collectively analyzed the video through whole class discussions. When engaging with the mathematics PSMTs completed tasks from the student perspective and discussed the core mathematical ideas embedded in the lesson. After watching the video of the enacted lesson PSMTs responded to reflective questions and utilized tools aligned to the teaching framework to analyze the mathematics teaching and learning. One of the tools, the *On Target*, is shaped like a bullseye and helps PSMTs situate teaching moves within different TRU dimensions. Each *On Target* provides a reflection question and lists teaching moves associated with one TRU Dimension. The outer rings provide examples of possible teaching moves less aligned, and the inner rings showcase teaching moves more aligned with the high-quality instruction defined by the TRU dimension. By using this tool, the PSMTs could focus their observations and use common language to reflect on what they saw in the video. All materials for the video case study analysis were grounded in a particular dimension of the TRU framework (Schoenfeld, 2017) to further assist PSMTs in developing teaching hypotheses aligned with powerful mathematics classrooms. This *On Target* tool was modified with permission from materials in development by the TRU group at the University of California, Berkeley (Schoenfeld & the TRU Project, 2018).

Data Collection and Analysis

Each of the class meetings in which PSMTs engaged with video case study analysis was video and audio recorded. After transcribing each meeting, we analyzed the data using thematic analysis (see Herbel-Eisenmann & Otten, 2011; Lemke, 1990). The course instructor, a graduate research assistant, and a second graduate student with expertise in the materials, began by open coding each session independently and then met to discuss and define emerging themes. From our thematic analysis six themes emerged: Understanding the Mathematics, Understanding TRU Tools/Dimensions, Understanding the Lesson, Recognizing TRU Dimension in Video,

Understanding Teacher Moves, and Connecting Teacher Moves a TRU Tool. The three researchers then coded the transcripts by identifying episodes related to the six themes. An episode is a portion of the transcript that focused on one particular topic. An episode ended when the focus of the talk changed. We then noted the number of episodes of each theme occurring over the course of the six sessions. Finally, the three researchers collaboratively engaged in a secondary analysis connecting the themes to Hiebert et al.'s (2007) skills to investigate the opportunities the PSMTs had to develop these critical skills of teaching.

Results

Through our secondary analysis, we identified relationships between our themes and the four critical skills for teaching. Table 1 shows this alignment and the frequency of each theme. The frequency of episodes suggested opportunities for the PSMTs to develop the critical skills for teaching while analyzing video case studies in their methods class. However, our most frequently observed theme did not align with the previously defined skills (Hiebert et al., 2007).

Table 1: Theme alignment to Hiebert et al. (2007) and number of episodes

Theme	**Alignment to Hiebert et al. (2007)**	**Number of episodes**
Understanding the Mathematics	No defined skill	33
Understanding TRU Tools/Dimensions	Skill 1 - Specifying the learning goals for the instructional episode	9
Understanding the Lesson	Skill 1 - Specifying the learning goals for the instructional episode	7
Recognizing TRU Dimension in Video	Skill 2 - Conducting empirical observations of teaching and learning	2
Understanding Teacher Moves	Skills 3 & 4 - Constructing hypotheses about the effects of teaching on students' learning; and (4) Using analysis to propose improvements in teaching	16
Connecting Teacher Moves a TRU Tool	Skills 3 & 4 - Constructing hypotheses about the effects of teaching on students' learning; and (4) Using analysis to propose improvements in teaching	19

Connecting Teacher Moves to a TRU Tool and Developing Skill 3

Our first example comes from PSMTs' discussions around a video case titled *Defining and Describing Quadrilaterals* that highlighted the TRU dimension of cognitive demand. After watching the video, the PSMTs were prompted to discuss their observations with the support of the related *On Target* tool (Figure 1) with the following reflection question: *To what extent are students supported in grappling with and making sense of the mathematical concepts*?

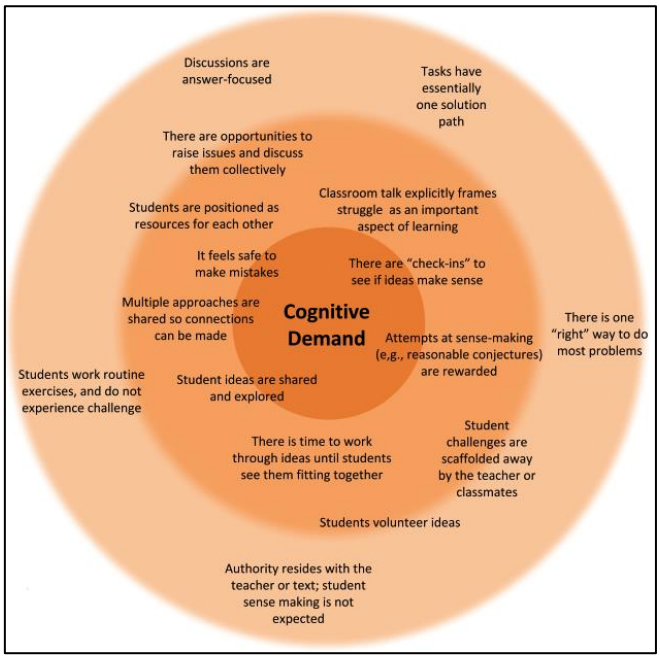

Figure 1. A version of the On Target tool discussed by PSMT-1 and PSMT-2 (recreated by authors)

PSMT-1: So we thought he was good because he stayed away from that outside things. Uh, one of the things we mentioned was how, um, for scaffolding moves students in productive directions without giving answers away, was like when the student said par…, like gave the definition for parallel, and instead of just like shooting him down, and being like, no that's wrong, he like, kind of like opened it up for everyone, you know, and like what does that really mean? And he kept moving forward that way, so that was good.

PSMT-2: And he also, he didn't scaffold them so much that it just took all the demand away. You know, it was, like he didn't just, you know, like PSMT-1 said, go off that one wrong answer and just tell everyone what it was.

This example shows two PSMTs unpacking Skill 3: constructing hypotheses about the effects of teaching on students' learning (Hiebert et al., 2007). By stating "stayed away from the outside things," PSMT-1 referred to teaching moves from the outer rings of the *On Target* that lowered the cognitive demand of a lesson. PSMT-1 stated that the teacher maintained cognitive demand through questioning moves that privileged and responded to students' mathematical thinking and did not funnel students toward one particular way of thinking. PSMT-2 built upon PSMT-1's observation and concluded that students are being provided the opportunity to grapple with the mathematical ideas in the lesson. This suggests that both PSMT-1 and PSMT-2 connected the teaching moves of maintaining cognitive demand to students' learning, the main focus of Skill 3.

Understanding the Mathematics and Defining A New Skill

During another session of the methods course, the PSMTs analyzed a video case titled *Representing Quadratic Functions Graphically* focused on the TRU dimension of formative assessment. PSMTs were asked to sketch two quadratic curves that "look quite different from each other." PSMT-3 drew a standard quadratic curve with its vertex at the origin, and the same quadratic curve rotated 90 degrees (see Figure 2), which prompted the following discussion:

Figure 2. PSMT-3's two different quadratic curves

I-2: The other one's not a function, right? That's a difference. Quadratic relation. Not a function.

I-1: [PSMT-3], do you understand what [I-2] just said there? About it not being a function?

PSMT-3: Yeah.

I-1: So what would be the difference between the equation you would have for those two then? Like you said the first one was $y = x^2$, what would be an equation for the other one?

PSMT -3: I don't know from the top of my head, to be honest.

PSMT-1: It would be a root of x, right? A square root? But that would only be positive. Half a circle.

I-2: Did you say half a circle? Can you say, what do you mean by half a circle?

PSMT-1: I have no idea how you would represent that, but it looks like half a circle. So it would make me think the equation of a circle, centered at whatever the center of that would be.

After viewing the video clip, the conversation returns to discussing the prior graphs. In the final minutes of the class, the instructor brings the students back to two graphs created by PSMT-3. The instructor challenges the class to come up with a quadratic equation that could represent the graphs. After a bit of discussion, the PSMTs continue to grapple with the content.

I-2: Can you think of an equation that defines this relationship? If this is y equals x squared, then can you think of an equation for this [referring to rotated graph].

PSMT-2: [To PSMT-1] What is that? $y^2=x$? Is that what you just wrote there? $y^2=x$?

I-2: Is this? Does that work?

PSMT-2: Yes. I was on Desmos trying to graph what I was doing but I made something really ugly. So no I mean what I was doing before, it was like just a whole bunch of lines.

I-2: Is that, is $y^2=x$ a quadratic relation?

PSMT-1: Yes.

I-2: Is there anybody who's not convinced that that curve is defined by y squared equals x?

PSMT-2: I'm convinced.

PSMT-1: Why are you convinced PSMT-2?

PSMT-2: Because I graphed it and it makes sense.

I-1: It looks like it.

PSMT-2: It makes complete sense.

These mathematical discussions suggest that the PSMTs were developing their own understanding of mathematics. Before watching the video, we see the PSMTs struggling with the task itself. They talk about the square root and a half circle, thus illustrating uncertainty with

what would constitute a quadratic relationship. After watching the video lesson, the PSMTs continue to unpack the meaning of a quadratic relationship and again return to the graphs created earlier. In this discussion, we continued to observe uncertainty around some of the mathematical concepts (e.g., inverse, function, relation).

As we analyzed this discussion, we recognized that our interpretation did not directly align with any of the four critical skills for teaching (Hiebert et al., 2007). This led to our defining a Skill 0, Understanding the Mathematics, defined as making sense of the mathematics for yourself, unpacking different ways others might solve a problem, and/or unpacking students' understanding of the mathematics. We contend Skill 0 to be an important component of PSMT learning that may precede the original four skills.

Discussion and Conclusion

The aim of this study was to explore opportunities for PSMTs to develop the critical skills of teaching in a methods class using video case studies rooted in a framework for high-quality instruction. Through our thematic analysis and subsequent alignment to the skills, we found several episodes of PSMTs' discussion that aligned to the four critical skills for teaching (Hiebert et al., 2007), suggesting an opportunity for PSMT development. Our most frequently occurring theme, Understanding the Mathematics, did not align with any of the previously defined skills as determined by Hiebert and colleagues. This finding suggests that PSMTs may require opportunities to think and interact with their own mathematical understandings since they must first grapple with these before understanding and hypothesizing about teaching moves and their impact on students' mathematical thinking.

Other researchers have also found that interrogating personal mathematical thinking is an important precursor for PSMTs developing skills for teaching. For instance, Graeber (1999) suggests that PSMTs must be able to provide alternative representations of mathematics for students as well as have the ability to recognize and analyze students' alternative solutions and approaches to solving mathematical tasks. She suggests that methods classes focus on providing opportunities for PSMT to explore various models and approaches to mathematical concepts in order to achieve this. Hine (2015) and Şahin et al. (2016) also note that PSMTs' mathematical understanding influences their ability to notice student misconceptions, offer alternate approaches, and assist students with deepening their understanding of mathematics. Therefore, we propose the addition of Skill 0 to the critical skills for teaching framework (Hiebert et al., 2007). Adding this skill to the existing framework has the potential to support PSMTs in developing the other four critical skills for teaching, such as constructing hypotheses about the effects of teaching on students' learning and proposing improvements in teaching.

One limitation of this study is that it existed in only two sections of a methods course taught in the same year with a small number of participants. This context does not allow us to make general claims about PSMTs' skill development. We therefore suggest future research to examine PSMTs use of video case study on a larger scale. Such research should focus on studying the connections between PSMTs' evolving mathematical understandings and their analysis of video cases to suggest how PSMTs are learning about the critical skills of teaching.

Even so, our work indicates that when designing a mathematics methods course, instructors should incorporate video cases with discussions rooted in a framework for high-quality instruction. These additional activities should also include time to focus on PSMTs understanding of their own mathematics. This focus is the avenue through which instructors can open up opportunities for PSMTs to develop the critical skills for teaching (Hiebert et al., 2007).

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