LEARNING INSTRUCTIONAL PRACTICES IN PROFESSIONAL DEVELOPMENT

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In this paper, we describe teachers' learning of an instructional practice related to launching a cognitively demanding task. Using a multi-case study design, we analyze eight teachers' participation in a rehearsal of the instructional practice in professional development and the ways these teachers enacted this practice in their classroom instruction. Our findings suggest that what teachers attended to in their rehearsal related to their classroom practice and the degree to which the cognitive demands of the task were maintained.

Keywords: Teacher Education-Inservice

Introduction

As a model of teaching, student-centered mathematics instruction supports students in engaging in tasks that build conceptual understandings, communicating and evaluating mathematical reasoning, and making connections among mathematical concepts. Such instruction has been shown to lead to increased student learning (Fennema et al., 1996; Boaler & Staples, 2008) and may address issues of equitable instruction for traditionally marginalized students (Myers, 2014). Though a consensus among researchers suggests that expert teaching involves understanding and using students' thinking to guide instruction (Bransford, Brown, & Cocking, 2000; Darling-Hammond, 2008; Kilpatrick, Swafford, & Findell, 2001), mathematics teaching in the US remains largely teacher directed, focused on procedures, and marked with few opportunities for intellectual engagement (Stigler & Hiebert, 2004; Wiess et al., 2003).

Professional development (PD) that relates new learning to teachers' practice can influence their instructional strategies (Darling-Hammond et al., 2009; Goldsmith, Doerr, & Lewis, 2013), yet many teachers have difficulties implementing new instructional strategies in their teaching. In PD, mathematics teacher educators (MTEs) have found that guiding frameworks for instructional practices are often insufficient to support teachers in enacting new practices in their classrooms (Boston & Smith, 2009; Munter, 2014). Recently, work around *rehearsal* in pre-service teacher education is showing promise as an approach for assisting novice teachers in learning and enacting student-centered instructional practices (Lampert et al., 2013). Our research adopts rehearsal as a pedagogy for supporting teacher learning of new instructional practices for a PD setting. In this paper, we aim to describe the ways a group of practicing secondary mathematics teachers attended to instructional moves for one student-centered instructional practice through rehearsal in PD. Specifically, our research is guided by the question: *in what ways does teachers' participation in rehearsal of an instructional practice in PD relate to their enactment of the practice in their classrooms?*

Background

A critical foundation for student-centered mathematics instruction is students' engagement with cognitively demanding mathematics tasks. Stein, Grover, and Henningson (1996) described the cognitive demands of a mathematics task as "the kind of thinking processes entailed in solving the task" (p. 461) and offered a framework for categorizing tasks as low and high cognitive demand. Their research showed that though teachers may begin instruction with a cognitively demanding task, the demands of the task often decline during implementation. Stein and Lane (1996) reported that the

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greatest gains in student learning occurred in classrooms where cognitively demanding tasks were implemented and maintained during instruction.

MTEs have developed frameworks for assisting teachers in maintaining the cognitive demands of tasks (e.g. Smith, Bill, & Hughes, 2008; Smith & Stein, 2011). Recently, Jackson and colleagues' (2013) investigated the relationship between task setup at the beginning of a lesson and the quality of the culminating discussion. They identified four factors that related to its implementation which were the degree to which: key contextual features were made salient; key mathematical concepts were highlighted and examined; a common language that supported contextual and mathematical elements of the task was developed; and the mathematical integrity of the task was maintained. We consider the practice of launching cognitively demanding tasks as paramount to teachers success in maintaining the cognitive demands of a task.

Theoretical Perspectives

We conceptualize PD as a boundary encounter (Sztajn et al., 2014; Wenger, 1998) where both the teaching and MTE communities bring distinct practices and identities. In a boundary encounter, teachers and MTEs come together to exchange knowledge by interacting around representations of knowledge that carry meaning in both communities called boundary objects. Members from differing communities introduce, negotiate, and integrate elements of their own practice as they interact and make new meanings of the boundary object together. From this perspective, teacher learning is taken as changes in their participation in the boundary encounter and the presence of new aspects of practice in their classroom teaching.

In PD, MTEs design professional learning tasks (PLTs) to facilitate participation around boundary objects (Edgington et al., 2015). Grossman and colleagues (2009) characterized PLTs as representations, decompositions, and approximations of practice. Representations, such as video or model lessons, refer to the ways MTEs make visible particular aspects of teaching. Decompositions refer to partitioning practice for in depth study, such as introducing a lesson or responding to students' thinking. Approximations of practice refer to opportunities for novices to engage in a particular practice, such as analyzing written work. Rehearsal is a particular kind of approximation of practice that supports novices by providing opportunities to learn about, practice, and reflect upon important aspects of practice while receiving in-the-moment feedback. Emerging research on the use of rehearsal has demonstrated its effectiveness in supporting teacher candidates in enacting particular instructional practices (Lampert et al., 2013;Tyminski, Zambak, Drake, & Land, 2014).

Building from this research, we design learning opportunities around boundary objects for instructional practices in our work in PD. We use a sequence of PLTs that begins with a representation of practice (e.g. experiencing a model lesson) followed by a decomposition of a particular aspect of that representation (e.g. debriefing the facilitation of a task). Next, we design a PLT that allows teachers to approximate the specific practice (e.g. rehearsing that practice with peers). One such PLT is a rehearsal. In our work, rehearsals have three interrelated components: teachers *rehearse* a particular instructional practice with their peers; receive in-the-moment *feedback* to support learning the practice; and *reflect* on their rehearsing and observations.

Methods

Our multi-case study investigates how teachers' participation in rehearsal relates to their classroom enactment of one student-centered instructional practice – launching cognitively demanding mathematics tasks. Case study research is useful for understanding a phenomenon bounded by a particular context and aims for its detailed description (Stake, 1995). To answer our research question, we first examined case teachers' participation in rehearsals and subsequent

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enactment in their classrooms. Next, we conducted a cross-case analysis to identify trends across case teachers rehearsals and enactments of launching cognitively demanding tasks.

Context and Participants

Our study is part of a multiyear PD and research project investigating secondary mathematics teachers' learning of student-centered instructional practices. The 108-hour PD was designed for a 10-month period, beginning with a 60-hour summer institute followed by 20 hours of face-to-face meetings and 28 hours of online work throughout the school year. In the summer institute, we shared several research-based frameworks for instructional practices that served as boundary objects through sequences of PLTs described above. As a part of the school year meetings, teachers were asked to plan and teach several student-centered lessons in their classrooms. This study focuses on teachers' learning the practice of launching cognitively demanding tasks.

Building from Jackson et al.'s (2013) four factors, we articulated a framework for the practice of launching cognitively demanding tasks. For us, the purpose of the practice is to ensure that students understand the mathematical goal of the task and can engage productively when the task is implemented without lowering its cognitive demands. The framework describes five instructional moves for launching: allowing think time (TT); checking for understanding (CU); addressing barriers for engagements (AB); sharing approaches (SA); and ensuring students can begin the task (BT). Allowing time for students to think about what the task is and what mathematical approaches they might take enables students to formulate a plan and identify additional information or questions they may have. Prompting students to share their interpretations of the problem ensures that students understand the task's mathematical goal. Addressing barriers provides an opportunity to resolve issues that may prevent students from engaging with the mathematics of the task during implementation, such as contextual questions, uncertainties about terminology, or mathematical skills not directly related to the goal of the task. Sharing approaches encourages multiple strategies and representations to be made public and allows students who may not have an approach to hear other's ideas. Ensuring that students can begin the task gauges whether enough students are confident about their approaches for the class to productively and collectively engage.

In the summer institute, each teacher completed one rehearsal to approximate launching. For each, three participants simulated "students" based on profile cards that outlined particular understandings, strategies, or barriers to engagement. One participant served as "teacher" and rehearsed launching the task. A MTE served as facilitator and provided in-the-moment feedback to the teacher while they rehearsed. Upon conclusion of each teacher's rehearsal, all participants reflected on what they learned by rehearsing and observing. During the school year, participants planned and taught student-centered lessons in their classrooms. These enactments served as a basis for continued reflection and discussion during the school year PD meetings.

Seventeen teachers from four suburban and rural school districts in the Southeastern United States volunteered and received a stipend for participation in the PD. Of the twelve teachers completing the PD, ten completed the activities used for this research, with eight teaching tasks of high cognitive demand. These eight teachers served as cases for this study.

Data Sources and Analysis

Data consisted of transcribed video recordings of the rehearsals and classroom enactments and written reflections following the rehearsals. We specified our unit of analysis as a teacher's talk turns in the transcripts and their written responses to reflection prompts. For the within-case analysis, we first coded each of these units in relation to the boundary object (TT, CU, BA, SA, and GS) to identify moves from the launching framework. Four researchers collaboratively coded the units for one of the eight case teachers, discussed discrepancies, clarified code definitions, and reached

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consensus. The remaining cases were double coded independently by members of the research team who then met and resolved discrepancies. This procedure allowed us to characterize each teacher's participation in the rehearsal in relation to classroom enactment.

For the cross-case analysis, we first used constant comparative methods (Strauss & Corbin, 1998) to identify noticeable trends relating teachers' participation in the rehearsal with their enactments. Next, we used a subset of the Instructional Quality Assessment (IQA) rubrics (Junker et al., 2006) related to Academic Rigor to determine the quality of the instructional task (AR1) and its implementation (AR2). After reaching agreement on three classroom videos with the IQA rubrics (IRR 88%), we used the IQA to rate the remaining lessons. To assess whether the cognitive demands of the task were maintained in the lessons, identical scores on AR1 and AR2 were taken to indicate that the cognitive demands of the task were maintained; a decreased in scores indicated a decline. Together, these two approaches allowed us to understand the relationships across teachers' participation in the rehearsal, their enactments in classrooms, and the maintenance of the cognitive demands upon task implementation.

Findings

Our cross-case analysis identified three trends in teachers' launches of cognitively demanding tasks. During rehearsal, teachers' launches varied in attention from addressing barriers to engagement to ensuring students' understanding. This variation corresponded to the degree to which their classroom launch attended to students' thinking and the degree to which the cognitive demands of the task were maintained. Instructional moves made in each teacher's rehearsal and enactment, and the maintenance of cognitive demands are summarized in Table 1.

Table 1. Instructional moves and related maintenance of cognitive demands.

	Rehearsal					Classroom Enactment					
Case	**TT**	**CU**	**AB**	**SA**	**BT**	**TT**	**CU**	**AB**	**SA**	**BT**	**Cog. Demand**
Eli		X	X	X	X	X	X	X	X	X	Declined
Mia		X	X		X	X	X	X		X	Declined
Cal	X	X	X	X	X	X	X	X		X	Declined
Tea		X	X	X		X	X	X	X	X	Maintained
Pat	X	X	X			X	X	X	X	X	Maintained
Ema		X	X	X	X	X	X	X	X	X	Maintained
Amy			X			X	X	X	X	X	Maintained
Ann		X	X			X	X	X		X	Maintained

Removing Barriers

Cal, Eli, and Mia used a variety of the instructional moves from the launching framework during rehearsal. Though they demonstrated the ability to use the moves as a tool to support them in launching, their launches had a marked emphasis on addressing barriers of context and language. During rehearsal and feedback, teachers' focus on barriers prevented them from the ultimate goal of launching– ensuring student understanding so that students may begin the task productively. Similarly, their reflections centralized the importance of addressing barriers without attention to the overarching goal of launching. For example, Eli began his rehearsal with the question, "Are there any words you do not understand?" He continued to focus on seeking out contextual and language barriers throughout his rehearsal despite feedback that encouraged him to move forward. The facilitator attempted to redirect Eli to move beyond barriers by saying, "So let's assume that issue is

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resolved and move on from there." He persisted with moves to clarify context through the end of the rehearsal. In his reflection, Eli stated, "What do you do when the issues don't go away? Redirect them with another question?" His primary focus on removing barriers overshadowed the ultimate goal of ensuring understanding and allowing students to engage with the task.

In their classroom enactments, Cal, Eli, and Mia demonstrated most of the launching moves. They proactively sought to resolve ambiguous features they anticipated would prevent students from making progress on the task. Though they were successful in addressing contextual and language barriers, this preemptive approach directed students' attention toward the mathematics central to the task, endorsed particular strategies, or supplied particular mathematical tools that resulted in a clear path for students to take to solve the problem. Additionally, in all three of these cases, the cognitive demands of their task declined. For example, Cal's lesson was organized around a task about landing an airplane with a goal of using trigonometric ratios to solve problems. Prior to introducing the task to his students, he discussed the context of plane flight and drew students' attention to mathematical features important to the task.

C: So what do you think as a pilot flying a plane or making a landing – what kind of math is going through a pilots head or should he be thinking about?
S1: A lot. The angle that the plane has to – the angle that you have to have the plane at when you're landing it.
C: The boy mentioned angles. What have we been talking about for 7 days? [S: Angles] Great. What else?
S2: Triangles.
C: How does a triangle work when you're flying a plane? How would it relate to flying a plane? How would it relate to flying a plane?
S2: Cause you're using the degrees.
C: Okay. Degrees.
S3: How high it goes?
C: Alright. How high you're going.
S4: How fast you gotta be going.
C: Speed. Okay, what else?
S5: How far you have until you gotta be up in the air.
C: Okay. So we've heard angles, triangles, speed, height. Okay. When you get this, keep your pencils down. Take a few seconds to read over it. Read over this, see what questions you might have after you read it.

In his attempt to contextualize the task prior to introducing it, Cal's attention to barriers he anticipated included the mathematical ideas central to his learning goals. His launching moves directed students towards a specific approach without allowing them the opportunity to consider other possibilities. During implementation, his students used triangles and trigonometric ratios as discussed in the launch to solve the task. The lack of ambiguity along with teacher-endorsed mathematical strategies led to a clear path for students to solve the task.

Though the rehearsal provided opportunities for them to try most of the launching moves, there was a marked emphasis on addressing contextual and language barriers. In their classrooms, their launching practice removed the ambiguities of the task that they anticipated and supplied students with the key mathematical concepts needed for the task. We infer that their focused attention toward removing barriers to engagement and supporting students in accomplishing the task successfully related to the lowering the task's demands.

Bartell, T. G., Bieda, K. N., Putnam, R. T., Bradfield, K., & Dominguez, H. (Eds.). (2015). *Proceedings of the 37th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*. East Lansing, MI: Michigan State University.

Emphasizing Understanding

Ema, Pat, and Tea also demonstrated many instructional moves from the launching framework during the rehearsal, but their participation differed in significant ways. Their rehearsals centralized the importance of ensuring students' understanding by integrating requests to re-voice the problem with responses to contextual or language difficulties that emerged. In their reflections, they noted the importance of students understanding the problem, addressing barriers, and making sure students could begin the task. For example in Ema's rehearsal, the first five questions she posed focused on ascertaining whether the "students" understood the problem. When a contextual barrier emerged from this questioning, Ema paused and the facilitator questioned her thinking. She responded, "in my head, I'm thinking I have to go back to what the problem is, but it was a good time to go ahead and get that [context barrier] out of the way." In her reflection, she noted the struggle of ensuring understanding while not overemphasizing aspects that were peripheral to the mathematical goal of the task in a timely manner.

In their classroom enactments, Ema, Pat, and Tea used all of the launching moves. Their emphasis on ensuring student understanding in the rehearsal led to moves that elicited and responded to their students' thinking about the task as it arose in the launch discussion. They worked to refine students' understanding of the task through questions like, "in your own words, what is the problem asking us to do?", clarifying terminology and contextual information, sharing different ideas about how to approach the task, and checking to make sure that students felt confident to begin working on the task. As an example, Pat began her lesson by allowing students time to think and discuss the problem. While listening to this discussion, she noted different students' questions and then strategically introduced them to the whole class.

P: Okay, I was asked a couple of good questions so I want to make sure that everybody hears the answers to them. Roman, will you ask your question first?
S1: Do you have to find out how much, how many toothpicks it takes to build all of the figures combined or just 1 individual?
P: Okay, do you all understand what Roman's question is?
S2: Yea, like the 8^{th} or all of the 8 together.
P: So he is asking, are you trying to find the number of toothpicks in general for just the 8^{th} or the 8^{th}, the 7^{th}, the 6^{th}… the 2^{nd}, and the 1^{st} all together. Which one do you think that we're trying to find?
Ss: [multiple responses aloud] "The 8^{th}," "all of them", etc.
P: Just the 8^{th}? [multiple responses aloud, "No," "Yea"] So from the… let's come to a consensus of what we think overall. I've heard a lot of people say just the 8^{th}. Which one do you think would make more sense? When you're normally trying, would you be finding, if you're trying to find your square, do you really care about all of the squares that came before it? [Students "no!"] Or just the specific square?
S3: Just the specific square.
P: Just the specific square. So let's go with the assumption that we're only trying to find that specific square. Ok Zack, what was your question?

Pat's launch continued by introducing other questions for whole class discussion, addressing contextual barriers as they arose, and ensuring that one member from each small group was confident to begin. Her integrated use of the launching moves suggests her attention to ensuring students understood the problem so that they could productively engage with the task.

The rehearsal provided opportunities to use the launching moves with a goal of ensuring understanding. In their classroom enactments, they addressed context and language barriers as they arose in discussion, had students share a variety of strategies for approaching the task, and verified

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that students could engage with the task. We infer that their attention toward ensuring students could engage with the mathematics of the task by eliciting and responding to students' ideas supported the maintenance of the cognitive demands of the task.

Removing Barriers to Emphasizing Understanding

Amy and Ann did not demonstrate many of launching moves during the rehearsal. Similar to Cal, Eli, and Mia, they focused almost exclusively on addressing barriers of context and language. Yet in their reflections, both noted the importance of not leading students through a launch and to leave the essential mathematical question open for students to resolve. In Ann's self-reflection, she stated that she learned, "how difficult it is to not directly lead the student to the solution." Similarly, Amy's reflection emphasized the difficulty of addressing "student misconceptions without leading their thinking too far into the task."

In their classroom enactments, Amy and Ann used most of launching moves to both respond to students' thinking as well as highlight anticipated barriers related to context and language. They provided time for students to think about the problem, probed to ensure students' understanding, and verified that all students could begin the task. Amy prompted students to publically share the approach they were going to use for the task.

For Amy and Ann, their attention when launching shifted from addressing barriers in rehearsal to emphasizing students' understanding in enactment. The rehearsal provided opportunities to reflect on the importance of listening and responding to students rather than leading to a particular approach. Their rehearsal was similar to Cal, Eli, and Mia – both teachers responded to students' thinking as well as highlighted anticipated barriers related to context and language. However, their enactments were more like Ema, Pat, and Tea. Their launches allowed students to engage with the mathematics of the task and maintained its cognitive demands.

Discussion

Our findings describe three ways secondary mathematics teachers participated in rehearsal of launching cognitively demanding tasks, enacting the practice in their classrooms, and whether the practice maintained the cognitive demands of the task. For teachers focused on removing barriers during their launches, their participation in the rehearsal related to instructional moves that lowered the cognitive demands in their lessons. For others focused on ensuring students' understanding, their participation led to a use of the framework in ways that maintained the demand. For Amy and Ann, participation in the rehearsal sensitized them to the importance of attending to students' thinking and led to launches that maintained task demands.

Our findings suggest that rehearsals are a viable pedagogy for MTEs to address the "problem of enactment." Opportunities for teachers to rehearse, receive feedback, and reflect on instructional practice may assist them in enacting the practice with students. Our results underscore the importance of clearly communicating both the moves and the purpose of a particular instructional strategy in PD. We urge PD designers and facilitators using rehearsals to carefully consider how they communicate the purpose of an instructional practice and align feedback and reflection opportunities with this purpose.

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