RESOURCES THAT PRESERVICE AND INSERVICE TEACHERS OFFER IN COLLABORATIVE ANALYSIS OF STUDENT THINKING

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This study examines a professional development (PD) program, set in a summer mathematics program for middle grades students with a research-based curriculum, where preservice and inservice teachers collaborated in interpreting and responding to student thinking. We investigated the resources that participants contributed to this collaboration, and the opportunities the non-traditional PD setting afforded for the sharing of these resources. Our embedded case study consisted of two classes, where participants taught and then engaged in video-recorded debriefing sessions each day. Their discussions focused on what they noticed in class and how they responded in the moment or anticipated responding in future lessons. We find that participants' observations from class catalyzed the sharing of resources, both from the program and from outside experiences, that contributed to the analysis of student thinking.

Keywords: Teacher Knowledge; Instructional Activities and Practices

Professional development (PD) focused on practice offers prospective and practicing teachers opportunities to learn and examine the real work of teaching (Ball & Forzani, 2009; Grossman et al., 2009a). Representations of practice (Grossman et al., 2009) captured in video episodes, student work, transcripts, and narratives are often used by researchers as effective tools to help unpack and decompose practice (e.g. Sherin & van Es, 2005; Kazemi & Franke, 2004; Silver et al., 2007; Oslund, 2016). Lacking in these studies, however, are opportunities to interact or be present within the dynamics of the context. Experiences such as lesson study (Lewis, Perry, & Hurd, 2009) provide direct access to the classroom with demonstration lessons that serve as representations of practice, followed by debrief opportunities for the decomposition of practice.

Little (2003) posits that improvement of teaching and learning is strengthened when teachers collaboratively engage in analysis of teaching practice. When representations of practice (Grossman et al., 2009a) are contextualized in a common work environment, they become resources for teacher learning. Researchers have noted differences in what expert, beginning, and novice teachers perceive and understand of classroom events (Berliner, 2001). This skill of professional noticing is an important component of decomposing core practices of teaching (Jacobs, Lamb, & Philipp, 2010). Our work examines a PD where preservice and inservice teachers taught together in an informal summer mathematics program and engaged in discussion sessions about the student thinking and teaching practices they noticed. We hypothesize that a "neutral" setting provides a productive space for negotiation of norms and practices across distinct cultures in which these groups are immersed: the preparation programs of preservice teachers, and inservice teachers' schools. Additionally, the program uses a research-based curriculum in which students construct understandings of pre-algebra concepts while using representations to explore problems and communicate their reasoning. We hypothesize that this curriculum creates opportunities for the analysis of students' mathematical thinking.

In this study we focus on two research questions:

1. What resources do preservice and inservice teachers contribute when discussing how to respond to students' mathematical thinking in a non-traditional setting?
2. What opportunities for the analysis of student thinking and the decomposition of teaching practice does a non-traditional collaborative teaching setting afford?

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Methodology and Theoretical Framework

Our study is an embedded case study (Yin, 2009) that took place in an informal summer mathematics program for students in grades 3-8 in the United States. In the two-week program, students took courses that explored pre-algebra concepts. Each class was taught by a "master teacher" (MT), an inservice teacher with multiple years of experience in the program, and assisted by inservice teachers seeking professional development (PDT), undergraduate preservice teachers (PST), and undergraduate "fellows" (F). The focus of our study is on the "teachers" at this summer program. The cases consisted of two classes collectively taught by two master teachers, three inservice PD teachers, six preservice teachers, and two undergraduate fellows.

During the program, inservice teachers and undergraduates taught together each morning, then convened after class in small groups, with each group consisting of the teacher and assistants for one class. In the meetings, participants responded individually to written reflection prompts, then engaged in videotaped group discussions about what they had observed in the day's class. We transcribed these discussions and divided the transcripts into conversational "episodes," with each episode focused on a unified theme or observation. We coded an episode as a *rich episode* if it included sustained discussion of students' observed mathematical thinking.

To address the first research question, we analyzed these episodes and identified how participants interpreted or suggested responding to student thinking. We also identified resources that various participants contributed to the discussion in each episode. In conceptualizing *resources* we use *mathematical knowledge for teaching* (MKT, see for example Ball, Thames, & Phelps, 2008) as an organizing framework. MKT consists of mathematical and pedagogical knowledge used in the work of teaching, comprised of components such as *specialized content knowledge*, *knowledge of content and students*, and *knowledge of content and curriculum*. Rather than attempt to sort resources into discrete MKT domains, we use these domains to orient our awareness of intellectual resources (Little, 2003) that participants use to make sense of student thinking, weigh possible responses, and understand the curricular context in which this thinking takes place. We take a grounded approach (Strauss & Corbin, 1997) in our analysis of resources, identifying and categorizing instances in which participants share knowledge and experience.

To address the second research question, we coded for instances in which participants made reference to features of the non-traditional context of the collaboration, either comparing this context with other mathematics teaching settings, or describing affordances or challenges of the context itself (such as opportunities for students to develop ideas prior to the presentation of formal procedures, or the fact that the program is not bound by the school calendar). We analyzed these instances for evidence that the non-traditional teaching context afforded opportunities for participants to make explicit their beliefs and dispositions about mathematics teaching (whether in their current non-traditional setting or in other more conventional settings) or their reasoning in interpreting or choosing how to respond to student thinking.

Results

In this section we describe some preliminary results of our analysis of the resources that teacher participants in the program offered in their discussions, and of the opportunities that the shared teaching context afforded for the collaborative analysis of student thinking.

Types of Resources Offered by Teacher Participants

In addressing the first research question, we offer three examples of categories of resources that have emerged from our data.

Awareness of alternative algorithms: a resource offered by PSTs. In Episode 3X_ 505, a group consisting of one MT, two PDTs, two PSTs, and two Fs discussed a fellow's observation of a

student who lacked access to an activity on the Pythagorean theorem because he did not know how to multiply numbers by hand. The group discussed different resources that might help the student. A PDT mentioned two students who had shared their own algorithms for multiplication to the whole class. Two PSTs indicated that they had learned about alternative algorithms, and the pedagogical value of these, in a content course for elementary teachers. Even though neither PST described any algorithms for multiplication other than those described from class, their awareness of the existence and value of multiple algorithms helped to frame the discussion of students' knowledge and use of non-standard algorithms in an asset-oriented way.

Knowledge of models and metaphors for operations: a resource offered by PDTs. In Episode 1Y_506, one MT, two PDTs, and one F brainstormed strategies for helping students understand integer subtraction; the fellow had observed some difficulty with the idea of subtracting an integer by adding its opposite. The participants launched into a discussion of possible ways to make the connection between subtraction and addition concrete for students:

PDT.155: You can think like banking terms I owe you an orange.
F.145: I think they kind of understood that a little bit when that was brought up …
MT.152: Yeah, and what if someone owes you, like we talked about bigger numbers, let's say that you have $25.00 … your brother had borrowed 20 of your dollars … Well, what if he paid you back – well, that's not subtracting …
PDT.180: Because we're subtracting –
MT.152: Do you see what I'm wanting? I want to subtract a negative to make it – I mean it is going back … Well, subtracting 20 – oh, I don't know. Okay, so I don't know. Anyway, think about that.
PDT.810: And he already owes you money. It would be like you're subtracting from his deficit, right?

The PDTs' contributions, rooted in pedagogical knowledge of common metaphors for the concept of integer subtraction (Quigley, 2011), added to the group's opportunities to develop a coherent explanation for why subtracting an integer is equivalent to adding its opposite.

Knowledge of the program curriculum: a resource offered by MTs. In Episode 1Y_203, one MT, one PDT, and one F discussed students' efforts to determine distances between numbers on the number line prior to the introduction of any formal procedure for integer subtraction. All three participants (MT, PDT, and F) commented that one student had shown evidence of beginning to realize that the distance from a negative integer to a positive integer could be found by adding the absolute values of the two numbers, but that she did not apply this principle consistently. The MT commented, "She doesn't have the rules down yet, which we're not even to yet … so, it's pretty cool that she's already getting it." The MT's comment referenced her curricular knowledge that formal procedures for subtracting integers and solving distance problems would come later in the summer course. This allowed her to frame the student's developing fluency as a stage of mathematical discovery rather than as a deficit.

Affordances of the Non-Traditional Teaching Context

Our analysis suggests that the shared context affords at least two distinct types of opportunities for in-depth analysis of students' mathematical thinking and of teaching practice.

The first type of opportunity emerges from the curricular context for the shared representation of practice. The program curriculum provides students with opportunities to use visual and tactile representations to explore problems, and postpones the introduction of formal procedures. As a result, teacher participants sometimes have opportunities to describe students' conceptual thinking about pre-algebra ideas without the backdrop of a normative procedure against which student performance might be compared. We see this in the example of Episode 1Y_203, in which the

absence of a formal procedure for finding distances on the number line afforded an opportunity for teacher participants to notice students' improvised methods for calculating distance, such as counting unit intervals on the number line and adding absolute values in the case in which the two endpoints are on opposite sides of the origin.

The second type of opportunity emerges from the contrast between the participants' shared teaching context and other contexts in which these participants had been mathematics teachers or learners. We find that the contrast among these teaching settings can provide the stimulus for a participant to make explicit their beliefs about mathematics teaching and learning. For example, in Episode 3X_505, in which teacher participants discussed a student who had difficulty with multiplication, several undergraduate students (PST and F) expressed surprise that such a student had been placed in an upper-level course in the summer program. They noted that the MT of their morning class (not present in the discussion) helped the student access the activity by providing a multiplication chart, but also stated that if they encountered such a student in a traditional setting, they would want to divert the student to remedial instruction. This afforded the MT an opportunity to provide a counterpoint for this deficit framing of the student, asserting that the activity's aim was to lead students to discover the Pythagorean theorem, not to assess multiplication, and that such an accommodation did not significantly undercut the mathematics.

Discussion and Next Steps

Our initial findings suggest that instances of non-standard student thinking serve to activate the unique knowledge resources of preservice and inservice teachers and offer opportunities for negotiations of teaching beliefs and norms across teaching cultures. Because the non-traditional structure and curriculum of the shared teaching context creates disequilibrium with the course-based preparation of PSTs and the more traditional teaching experiences of inservice teachers, participants from both constituencies are encouraged to make explicit their own initial conceptions of students' thinking, mathematical dispositions, and attitudes (Figure 1).

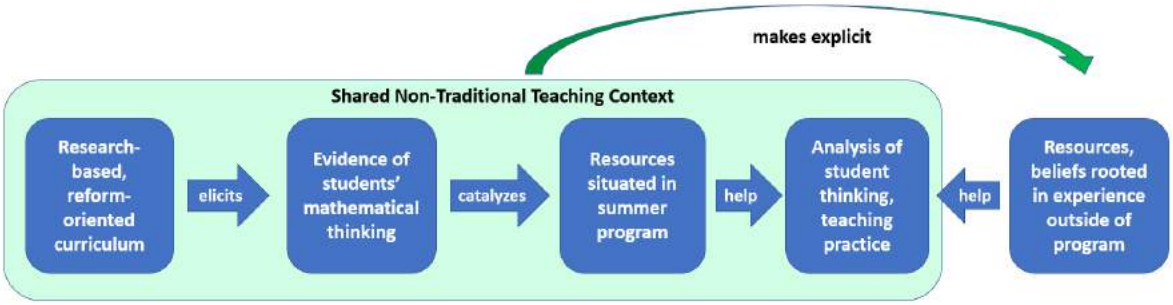

Figure 1: Model for the role of a shared non-traditional teaching context in PD.

Next steps for our study include a more thorough synthesis of the types of knowledge resources that participants contribute to the collaborative analysis of student thinking, along with an analysis of the degree to which these resources are differentiated by participant type (MT, PDT, PST, F). We also plan to develop a more robust coding scheme for assessing the role of the non-traditional setting in activating (or muting) the external resources, such as preservice teacher experiences and knowledge of traditional curricula, that participants bring into the program.

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