Learning to teach within practice-based methods courses

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Supporting prospective teachers to enact high quality instruction requires transforming their methods preparation. This study follows three teachers through a practice-based elementary methods course. Weekly class sessions took place in an elementary school. The setting afforded opportunities for prospective teachers to engage in cycles of investigation and enactment. The course was focussed on learning teaching practices through planning, rehearsing, enacting and reflecting on routine instructional activities that travel back and forth between field-based methods course and field placements. All three teachers grew in their capacity to lead goal-directed lessons by eliciting and responding to students' thinking. Our analysis connects the teachers' learning to the intentional design of the methods course.

Keywords · prospective teachers · practice-based teacher education · methods coursework · elementary teaching · teacher education

Introduction

When Ball and Cohen (1999) painted a vision of centring professional learning on practice, they argued that it entailed "identifying the central activities of teaching practice and selecting and creating materials that usefully depict that work" (p. 13). Our ideas about supporting teachers have continued to grow in the last 15 years, and we are experiencing a renewed effort to ground teacher preparation in clinical practice (Hunter & Anthony, 2012; Korthagen, 2010; Grossman, 2005; McDonald, Kazemi, & Kavanagh, 2013; National Council for Accreditation of Teacher Education, 2010). Both conceptually- and empirically-based arguments have led researchers to argue for developing pedagogies of practice that encompass ways of learning to both analyse and enact practice (Grossman et al., 2009).

This paper reports on the learning experiences of three prospective teachers (PTs) in a practice-based course that was significantly redesigned to develop teacher knowledge and performance (see also Zeichner, 2010). We ask: How did PTs develop in their teaching of ambitious practices as envisioned by the mathematics methods course? Our argument is that close examination of three students' experiences illuminates what is possible in PTs' learning, what is challenging, and what needs to be made more explicit as we continue to refine and improve pedagogies of practice.

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What we have learned from studies of prospective teacher learning

Discussions about knowledge and practice, in teacher education, have often centred on the relationship between methods instruction and field experiences, and an oft-cited concern about where the "real" learning lies (cf. Zeichner, 2010). Our work is informed by major developments in the literature on teacher education, specifically the kinds of supports that scaffold PT learning. As background to our new designs for methods instruction, we highlight key studies that exemplify important shifts in the way we have understood the relationship between methods courses and field-based teaching. In a widely-cited paper published 20 years ago, aptly titled—"Learning to teach hard mathematics: Do novice teachers and their instructors give up too easily"?—Hilda Borko and her colleagues (1992) examined why a sixth grade mathematics lesson on the division of fractions taught by a PT failed. Failure, in the context of that study, meant that the teacher was unsuccessful in helping students develop a conceptually based justification of the algorithm for dividing fractions. Borko et al.'s analyses led them to conclude that several factors were at play, including the failure of the teacher's methods course to support her to reorganise her beliefs, and develop conceptual and pedagogical knowledge for teaching. It is not surprising that this study ends with recommendations that teacher preparation programs take more seriously opportunities to expand subject matter knowledge, develop pedagogical content knowledge, and challenge PTs' beliefs about the nature of learning. Developing knowledge remains a concern in the field today but our frames for shaping PT learning have developed in important ways.

Nearly ten years after Borko et al.'s paper, Ensor (2001) published a paper following seven students through a secondary methods course in South Africa. Like Borko et al., she acknowledged that PTs' own beliefs and their school contexts shaped their early practice. But, importantly, she also investigated the structuring of the methods course. She found that the methods course helped her students develop a professional argot, a way of talking and thinking about mathematics teaching. However, PTs had very little support in recontextualising their new ways of talking and thinking about mathematics teaching. By recontextualising, she means that there was little intentional support in helping PTs relate discourses from one social context (the math methods course) to another context (classroom teaching). Ensor's observations exemplifies what Mary Kennedy (1999) calls *the problem of enactment*, or the gap between what PTs can consider and what they are able to do.

In the last decade, literature on teacher education has argued for developing our preparation programs so that we better support PTs to develop and deploy knowledge in teaching. A study of cross professional preparation led Grossman et al. (2009) to conclude that the field of teacher education needed to develop pedagogies of enactment, joining them with existing pedagogies of investigation (e.g., Merseth, 1991). The fundamental aim of such a proposal is to better support teachers in learning how to use knowledge in action (Ball & Forzani, 2009, Cook & Brown, 1999; Grossman, Hammerness, et al., 2009; Lampert, 2010; Zeichner, 2012). In recent years, a growing group of scholars in the field are experimenting with methods to organise the work and scholarship of teacher education around what they refer to as core practices of classroom teaching. By highlighting specific, routine aspects of teaching that demand the exercise of professional judgment and the creation of meaningful intellectual and social community for teachers, teacher educators, and students, core practices may offer teacher educators powerful tools for preparing teachers for the constant in-the-moment decision-making that the profession requires. What PTs will learn from designs that are informed by this view needs to be studied, and this paper contributes to that effort.

Framework for course

Design of course

The design of the mathematics methods course, described in more detail in the next section, is based on a vision of ambitious instruction and is an outcome of a collaboration among researchers at three US universities (see Lampert et al., 2013). In our view, ambitious teaching entails mathematical meaning making, identity building, and striving towards creating equitable learning experiences. Ambitious teaching requires teachers to engage deeply with children's thinking—eliciting, observing, and interpreting student reasoning, language, and arguments and to adjust their instruction accordingly to promote learning. It requires attending to students' experiences, supporting meaningful participation in mathematics for the broad range of children in any classroom, and working to disrupt longstanding assumptions about who can and cannot do math (e.g., Aguirre Mayfield-Ingram, & Martin, 2013; Cengiz, Kline, & Grant, 2011; Gutiérrez, 1996; Hunter & Anthony, 2011; Lampert, 2001; Parks, 2010; Stein, Grover, & Henningsen, 1996). The course was designed to respond to perennial issues in teacher education regarding the gap between theory and practice and the need to help PTs not only develop their pedagogical content knowledge but also learn how to put that knowledge into practice (see Zeichner, 2012). As the reader will notice, it incorporated cycles of co-planning, co-teaching, and reflecting on teaching present in other professional development efforts for practicing teachers such as Japanese Lesson Study (see Fernandez, 2002) and instructional coaching (Neufeld & Roper, 2003).

Principles and practices

Our design closely ties "coursework" and "fieldwork". To learn the practices, principles, and knowledge that constitute our intended curriculum, and to learn to use them adaptively in relationships, we teach PTs to enact particular instructional activities (IAs) that travel back and forth between field-based methods courses and field placements (see Table 1; Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2010). These activities serve as *containers* for the practices, principles, and mathematical knowledge that PTs learn and are able to use in interaction with students. The structure of the IA scaffolds the teacher to elicit student understanding of mathematics and to make judgments about how to respond in principled, instructive ways. While bounding the complexities the PT will encounter, the IAs are designed to enable the participation of a broad range of students; to enable teachers to elicit and build on particular students' mathematical thinking; and to work on a range of mathematical ideas in number and operations in the elementary grades.

Frame on Learning

Our work is informed by sociocultural views of teacher learning. Understanding learning as it emerges in activity is central to this perspective. We draw on Lave's (1996) description of learning, thinking, and knowing as "relations among people engaged in activity in, with, and arising from the socially and culturally structured world" (p. 67). Shifts in participation make visible the learning that is occurring as people engage in practice (Lave & Wenger, 1991; Rogoff, 1997). Learning, in this view, is not just about acquiring new knowledge but also developing the ability to engage in particular practices and developing professional identities. Learning is not a value neutral activity. Prospective teachers bring their own histories forward as they engage with a new set of experiences and thus they simultaneously shape and are shaped by their participation. Our stance towards teacher learning is to use our analyses about what PTs seemed to learn from the course to press on how the structuring of the course may have shaped teacher responses. Following from this view, we did not attribute any perceived lack of appropriation to the teachers' shortcomings. Instead, we examined the relationship between settings, what practices were valued, and how PTs were beginning to form their professional identities.

Description of Course

We provide details below about the methods course structure, which took place in the second of five terms of a graduate level teacher certification program, to underscore the complex way that time and collaborative groupings were organised. The mathematics methods course began with two full days of class held at the university (each six hours in length), during which time PTs were introduced to the principles that guided the substance of the course, core ideas of Cognitively Guided Instruction (CGI; Carpenter et al., 2014), and the instructional activities they would learn during the term (see Table 1). CGI frameworks for children's thinking formed the backbone of the course because of their well-documented impact on teachers and student learning (e.g., Carpenter et al., 1989; Franke et al., 1998; Franke et al., 2009). All subsequent sessions of the course were held in the library of an elementary school, a school partner of the teacher education program. The instructor had a formed a partnership with one teacher and her fifth grade class at that school. The methods class met at the elementary school for four hours every Tuesday for ten weeks. A second term of mathematics methods took place at the university. PTs continued to learn about lesson planning, unit planning and adapting curriculum materials to meet grade level expectations. This article focuses on PTs' experience in the first term of mathematics methods held at the elementary school.

Table 1
Guiding Principles and Instructional Activities for the Course

Principles	1. Children are sensemakers. 2. Teaching includes becoming a student of your students. Teachers must know their students as individuals and as learners. 3. Teachers must design instruction for each child to do rigorous academic work in school and to have equitable access to learning taking into account the range of social skills, community capital, and linguistic resources students bring to the classroom. 4. Ambitious instruction requires clear instructional goals. 5. Teachers must be responsive to the requirements of the school environment. At the same time, they must wrestle with why schools function as they do and how schools might need to improve as institutions in a democracy.
Instructional Activities*	**Quick Images** are designed to engage students to visualise numbers and form mental representations of a quantity typically presented through a configuration of dots. Students explain how they organised and subitised quantities in order to count the total dots in the image. **Choral Counting** is a classroom activity during which the class counts together by some increment, forwards or backwards, while the teacher writes the count in a particular configuration of rows and columns on the board. The teacher stops the count at strategic points for students to discuss patterns emerging in the count, make predictions using those patterns, and/or explain why the patterns are occurring. **Strings** are intentionally sequenced computation problems designed to focus talk on specific strategies or properties of operations. Students solve the problem, then share and defend their solutions and strategies. **Launching Problems** refers to introducing the task to students in a way that supports them to have an entry point. Launching typically requires supporting students to attend to mathematical quantities and their relationships and key contextual features of the problem. **Teaching with Games** involves introducing how to play a mathematically rich game, structuring play in pairs, and monitoring students to have focussed interactions with students about strategic game play.

*see tedd.org for examples of these IAs and planning protocols.

PTs were divided into 4 teams of 8 participants. The team structure enabled them to work together in planning, enacting, and debriefing course tasks. For the first five weeks of the term, each session focussed on one IA. The class was structured in the following way:

1. Teams of PTs came to class prepared to lead an IA, went over their plans, and then rehearsed the IA under the supervision of a teacher educator (the course instructor, teaching assistants or the cooperating partner teacher).

2. PTs observed the course instructor and cooperating partner teacher co-teach the whole class. PTs participated in the lessons as they sat with their fifth grade "buddy" listening in on children's mathematical conversations or interacting during pair share talk.
3. Two PTs from each team co-taught a small group of fifth graders the IA that they had come to class prepared to teach. These lessons were videotaped. A teacher educator (TE) also observed the enactments and occasionally interjected moves to support lesson enactment.
4. After a break, which sometimes included going out to recess with the fifth graders, PTs met in their teams to review the videotapes with the teacher educator, pausing the videotape to comment or ask questions about instructional decisions.
5. The cooperating partner teacher and methods instructor shared some of their reflective comments on the whole group lesson that was taught and small groups debriefed what they learned from the week's enactment.
6. The methods instructor prepared the class for the following week's focal IA.

For the last five weeks of the term, class time for the fifth graders was organised into four rotating small group activities, each lasting 12-15 minutes: (1) games (2) quick images (3) problem solving, and (4) strings or choral counting. In order to provide repeated opportunities for practice, the PT teaching teams each took charge of a small group of children, and four teams of children rotated to engage in their lesson, enabling pairs of PTs co-teach one of the rotations. A teacher educator helped PTs rehearse, enact, and debrief the rotation.

Method

Selection of informants

We picked one of the four teaching teams at random and then selected a primary, intermediate, and upper grade teacher within that team of eight whose participation and work we followed across the methods course. A case study approach (Yin, 2008) was well suited to our questions because we were interested in a detailed analysis of the experiences of particular students as a way to understand how the design of the course was shaping particular trajectories of learning. Cross-case analysis of our three participants—Allison, Andrew, and Lorena—enabled us to expand our understanding of participation in the course and raise theoretical questions about PT learning through practice-based methods.

Data collection

Data collection began during the second session at Pinehurst Elementary School to provide time to explain to the candidates the purposes of the study and obtain consent. We collected the following artefacts of PTs' work: (1) math autobiographies written prior to the beginning of the course that chronicled participants' own experiences with mathematics and their attitudes about teaching and learning mathematics, (2) weekly written reflections, and (3) the end-of-course course project which was an annotated video of what participants learned.

We observed and videotaped two rehearsals in which Allison and Andrew were lead teachers. Because of technical difficulties, we did not have a video record of Lorena's rehearsal. We also analysed ten co-taught enactments of the instructional activities spread out over the term. The PTs were asked to take turns teaching, but in the end, among this group, it turned out that Andrew did not teach as many times as the others: Allison (6), Lorena (4) and Andrew (3). We were not aware of this difference during the course. We also observed and videotaped seven occasions of team debriefings of the PTs own enactments of the IA, and a structured group reflective dialogue that took part in the middle of the methods course.

At the end of the methods course we observed and videotaped each PT enacting an IA at their own field placement. Immediately after the lesson, we interviewed the PTs. The PTs reflected on their lesson by playing back the video-recorded enactment. The PT paused the video when he/she wanted to make a statement about what he/she was thinking. Alternatively, one of the authors paused the video intermittently to ask questions about the PT's thinking. These interviews were also videotaped.

Coding and data analysis

To understand PTs' learning trajectory, both the advances and challenges that they faced, we analysed the data corpus for (1) how they appeared to try out the instructional practices the course aimed to help them learn and (2) how they identified with the principles of the course.

The use of Studiocode© video-analysis software allowed for detailed coding of the PTs' participation both within and across video-recorded rehearsals, enactments of IAs both at the partner school and in the PTs' own placement, and team debriefings of lessons. It also allowed for multiple analytic passes to track changes in PTs' participation that occurred during the methods course. We created timelines for each video-recorded incident to capture the PTs' use of common practices of ambitious teaching and their interactions with TEs, other PTs, and children and to code what was being worked on within these incidents. Coding the video directly allowed for both verbal and visual cues to be considered, such as written representation, gesturing, and movements, to capture what was worked on and how it was worked on.

We documented changes in how the PTs participated in a number of aspects of the activity of ambitious mathematics teaching, and how the PTs developed in their understanding and identification with such teaching. We started the analysis of video records by coding for seven practices of ambitious teaching that were explicitly worked on during the course: aiming toward a mathematical goal, eliciting and responding to students' mathematical ideas, orienting students to each others' ideas, setting and maintaining expectations for student performance, positioning students competently, assessing students' understanding, and using mathematical representations. Our codes indicated that the aims of the course were visible in the interactions. Additional codes emerged from the data that captured important aspects of PTs' teaching practice: responding to student error, learning about student thinking, aiming towards process goals, aiming towards content goals, monitoring student responses, launching problems, supporting student collaboration, working on PTs' own math knowledge, and developing new insights during debriefings. Table 2 shows a list of the codes that we built our analysis on.

Table 2
List of Relevant Codes

Code	Description
Elicit and respond	Eliciting, interpreting and responding to student reasoning during individual work and discussions
Aim toward goal	Drawing attention to and directing students toward the learning goal
Math process goals	Attending to process goals such as student reasoning, sharing strategies, generating multiple strategies
Math content goals	Attending to specific mathematical content goals, justifying reasoning, and comparing different student solutions
Student error	Surfacing and responding to student error
Student thinking	Attending to details of student mathematical thinking.
Monitoring student responses	Monitoring student responses and selecting particular students to share their work
Use of talk moves	Making use of talk moves to orchestrate discussions: Revoicing, repeating, reasoning, adding on
Launching problems	Launching problems in a clear and structured way. Discussing key contextual features of the task. Communicating with students during launching phase and assessing students' understanding of the task statement
Use of representation	Attending to the use of representations and making connections between different kinds of representations. Representing mathematical ideas in writing and making connections between talk and representation
Facilitate collaboration	Facilitating student collaboration. Making use of turn and talk
PTs' own Math knowledge	PTs' understanding of mathematical content
New insight during debrief	Changes in PTs' understanding of different aspects of ambitious teaching during debrief

After coding was complete, we made several analytic passes through the data, compiling data segments according to their codes and reviewing the entire corpus qualitatively. We also wrote case reports for each participant summarizing their own views on their learning by examining their written work from their courses and their post-lesson interviews. We made matrices that enabled us to track changes in participants' practices and wrote analytic memos to help us connect the varied sources of data—observations, interviews, and participants' own writing. This process enabled us to identify three salient dimensions of practice that were worked on over the course: managing interactions with students, particularly in eliciting and responding to their ideas; using representations as means to support the mathematical ideas being worked on; setting up tasks to facilitate entry into the problem for a broad range of students without reducing the intellectual work (Jackson et al., 2013).

Results

In this section, we provide case descriptions of each of our focal participants. For each participant, we describe how their practice shifted over the term and discuss what remained challenging for them according to the three themes that emerged from our analysis. We do this in order to better understand what was possible in PTs' learning, what was challenging, and what needs to be made more explicit as we continue to refine and improve the design of practice-based methods. We would like to emphasise that by the end of the methods course, the PTs remain in the early stages of learning the practices of ambitious teaching. Thus, we were looking at a small part of their learning trajectory. Even so, our analysis revealed noticeable changes regarding many aspect of ambitious teaching, and in this paper we focus on those aspects.

In their autobiographies all three PTs reported having positive experiences with mathematics. However, Lorena said that as a mathematics learner, she sometimes needed extra time. Both Allison and Lorena talked about how they wanted the students to understand mathematics. Only Lorena also talked about student enjoyment. All three PTs expressed having experiences in the course that helped them start to appreciate the value of learning about students' mathematical thinking.

Allison

Allison led six enactments of instructional activities at Pinehurst in the following order: choral counting, problem solving, games, strings, problem solving and quick images. Allison taught problem solving when we observed her in her own field placement at the end of the first term.

Managing interactions with students. Over the methods course there was a noticeable change in the way Allison elicited and responded to students' responses. In her first enactment Allison elicited different students' strategies and she listened carefully to students' explanations. The focus was on sharing student strategies. "Can you explain what you did"? "Who did it differently"? Allison did not press the students by asking "why" questions, nor did she ask students to compare their solutions to one another. During the second enactment, the TE interjected during Allison's teaching to illustrate possible moves she could make to compare different student strategies and to direct the students toward specific content goals. The students in Allison's small group had each solved a word problem modelled by the expression 15 x 12. The TE interjected to provide an example of how to orient students to each other's work by raising a mathematical question about how each student accounted for the 15 groups of 12.

TE: How do you count the 12s in Steven's picture? How is he counting those 12s? Because Peter is counting the 12s by doing 12 12s at one time, or you could think about 10 12s and another five 12s. We are also counting 12s there, but hmm, that sure is a little different way of counting 12s. I wonder if you guys could look at that and think about how you are counting those 12s. (Second enactment, problem solving, Oct 25, 4th class session)

Allison responded to this comment by the TE by asking further follow-up questions for students to notice how the 12s were accounted for. At the end of the methods course, when she was teaching her own class at the practice school, Allison monitored the students' responses. She then selected particular students to share their work to discuss differences and similarities between strategies, asking "Can you tell me what was different about the way George solved the problem and the way Anna solved the problem"? Further, Allison used students' thinking as a starting point for the discussion in whole group and she attended to the details of students' mathematical thinking. Examples of questions were "What do you mean when you say the rest"? and "Could you have shown that with just one group"? The focus was on developing conceptual understanding.

Allison: We all agree that it is eight. So Evan, can you share with us how you got the answer of eight?

Evan: I built a tower of unifix cubes, and I took three off and then another three and then/

Allison: Wait a second. Slow down. So you made a tower of unifix blocks. How many did you put in that tower?

Student: I put 15.

Allison: Why did you put 15?

Student: Because that was the number you said and I took seven off and then I counted the rest. And it was eight.

Allison: So Liz, can you describe to me what Evan did? (Teaching at practice school, problem solving, Dec 12)

In this exchange, Allison asked specific follow up questions to understand what a student was doing and invited another student, in the position of listener, to repeat what Evan did, thus putting into play Evan's strategy for further consideration.

The data show that over the methods course Allison became more aware of the importance of anticipating student responses and preparing possible questions in advance. In her reflection during the seventh class, Allison commented on the importance of making purposeful choices about what ideas to share in order to achieve the mathematical goals for the discussion. In the post-lesson interview at the practice school she stated that anticipating students' responses is something she needed to continue to work on.

Allison: ...I am still not really sure what this group, what kind of answers they are going to come up with and how they are going to differ. Whereas at Pinehurst where you got so close up with the six students I was able to think about how everybody would solve the problem. ….I am still learning how they (her students) respond to certain problems.

...

Allison: This is kind of a new thing for them (students) and I think that I want to do more of this type of [small group work] with them and just think more strategically about the questions that I am asking. (Post-lesson interview at practice school, problem solving, Dec 12)

She stated that observing and learning more about students' responses would positively affect her planning regarding what questions to ask and what content goals to attend to.

In all teaching sequences we analysed for Allison, the launching phase was followed by a second phase in which students worked individually on the problems. Allison did not encourage the students to turn and talk or collaborate in small groups. With only one exception, student sharing of ideas and strategies only took place with the entire group. There was no change regarding this as the course progressed.

Setting up tasks. We saw shifts in Allison's practice of launching problems in order to make the task comprehensible to students and to give them a starting point. In her first and second enactment, when Allison was teaching choral counting and games respectively, she presented the problem to the students in a clear way but did not follow up with students to check for understanding. During the rehearsal before the fourth enactment the TE scaffolded the launching by illustrating how the teacher could phrase the problem to help students to see the relation between the two problems. We join the rehearsal as Allison tells the children they are free to draw a picture if it is helpful.

Allison : If it is helpful for you to actually draw the picture you can go ahead and do that. It is going to be really helpful when we are solving this next problem. Really think about the picture that I drew. So our next problem is 25 times 16.

TE: … I would actually say:" I want you to really think about how my picture is going to change". That is what I want you to work on rather than well maybe you would use the picture. (Rehearsal before fourth enactment, strings, Nov 15, 7th class session)

In this interjection, the TE offers a more targeted suggestion to all of the students. Instead of Allison's open-ended one –that students may want to use the representation–the TE suggested that students think about how the visual will change as a new problem is posed.

As the methods course progressed, Allison was very conscious about the way she formulated the problems and she communicated more with the students during the launching phase, e.g. by asking questions to make sure that the students understood the problem and by discussing key contextual features in the problem. We drop in as she begins to talk to students about a word problem.

Allison : ... So this survey says that people in the United States watch an average of 220 hours of television in a month (reads from the board). And I talked to Miss H and I said, "Do you think people watch 200 hours of TV in a month"? Do you guys think you watch that much?

Student: I watch more.

Allison : Do you think you watch more? Does anyone think you watch less than that? (Some students raise their hands.) So when it says average, does that mean that everybody in the US watches 220? (Fifth enactment, problem solving, Nov 29, 9th class session)

In the example above Allison tried to elicit how students interpreted the idea of average number of hours. We observed her discuss the importance of attending to student interpretation in her own field placement as well. During the post-lesson interview at her own school, Allison emphasised the importance of the wording of the problem and reflected on how the phrasing of the problem might influence students' strategies.

Using representations. Making use of different representations—such as arrays, tally marks and the open number line—as a way to make public records of students' thinking was a central aspect of the methods course. In her first and second enactments, Allison represented students' thinking on the board. Moreover, she focussed on the relation between the representations and the context, e.g. "What does each of these boxes represent in the problem"? However, she had some difficulties with using representations to promote students' understanding of important mathematical ideas. The TE intervened frequently during the rehearsal before her fourth enactment suggesting ways to structure the different representations in a clear and organised way. The TE also scaffolded Allison's use of representations by illustrating how she could use the drawings to orient students toward the mathematical content goals of the lesson.

Allison took up these moves in her teaching and started attending to the use of representations. Her transition was supported not only by the TE's interventions but also by monitoring students' responses. At the end of the term, when Allison was teaching her own class in her field placement, she selected students with strategies that represented the mathematical situation in different ways to share their work, and she tried to promote student understanding of how the various representations connected with each other. Her focus was on facilitating students' understanding of important mathematical ideas.

Summary. Over the methods course there was a noticeable change in the way Allison participated in aspects of ambitious teaching. She conveyed a sense of identification with the aims of ambitious teaching and she was very confident in her knowledge of mathematics. At the end of the methods course Allison pursued questions that pressed students to develop mathematical justification. She attended to the use of representations and made connections between different kinds of representations as she steered instruction towards meeting instructional goals. In the post-lesson interview at the end of the term, Allison made detailed analysis of students' learning, how the instruction might have influenced student learning, and made meaningful suggestions for her own improvement.

Lorena

Lorena led four enactments of instructional activities at Pinehurst in the following order: choral counting, problem solving, problem solving, and quick images. Lorena taught problem solving with the use of strings when we observed her at the practice school.

Managing interactions with students. Over the methods course there was a noticeable development in the way Lorena elicited and responded to students' responses. In her first enactment, when Lorena was teaching choral counting she asked the students for patterns "What patterns do you see"? However, she did not ask the students to explain their thinking, and she did not pursue the connections between some of the suggested patterns. The following excerpt comes from a backwards count by 10 starting at 573 (see Figure 1).

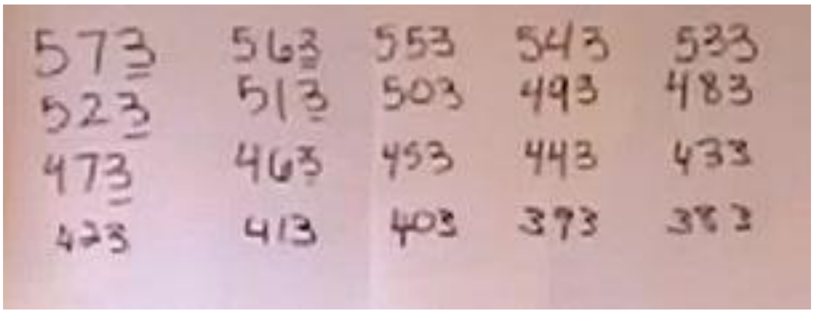

Figure 1: Counting by 10s starting at 573

Lorena:	Juan, what patterns do you see?
Juan:	Seven, two, seven, two in the tens place.
Lorena:	So here? Seven, two, seven, two. (Underlines the sevens and the twos) Okay.
Juan:	And the next one changes by six, one, six, one.
Lorena:	So in the tens place you see six, one, six, one? (Underlines the numbers). Okay. Very good.
	...
Lorena:	What pattern do you see, Damien?
Damien:	It goes down by 50.

Lorena: What goes down by 50?
Damien: 83, 33, 83, 33.
Lorena: So, Juan, can you tell me what Damien said?
Juan: Eh, what did you say?
Lorena: Could you repeat what you said, Juan?
Damien: I said it goes down by 50.
Lorena: What goes down by 50?
Damien: 83, because/
Lorena: So if I say here 83. Oh, so you are saying 83, so right here to right here you say it goes minus 50? (Draws on the board).
...
Lorena: So, Sarah, what's another pattern that you see?
Sarah: I see 73, and then 23, and 73. (First enactment, choral counting, Oct 11, 2nd class session)

Lorena did not make any connections between the patterns suggested by the three students although there are all about going down by 50.

As the methods course progressed, Lorena became better at eliciting student strategies, asking the students to explain their thinking, and selecting students to share their strategies. Typical questions were "Could you explain what you did"? and "Did somebody else see another way of doing this"? She was using students' thinking as the starting point for the discussions and she was listening carefully and patiently to student explanations. However, although Lorena sometimes asked students about similarities "Can you see any similarities between the two"? she did not use follow up questions to elicit the details of students' reasoning. It was also challenging for her to make connections between students' strategies and the specific content goals of the string we observed her teach at her practice school.

She commented that it was challenging to elicit students' strategies and direct them toward the two different multiplication relationships that could be discussed in the string: (1) doubling one factor and halving the other and (2) using the tenth multiple to figure out the ninth.

Lorena: And that was what was confusing me, the transition. How do I transition them to the next? Because there were two different relationships.
...
TE: It is something to think about with the number talks, when you look in the book and you try to pick them. Sometimes there is more than one relationship that is being worked on. It might be easier not to do that. This is an interesting thing to think about for me too. When you are first trying them out, stick with one. (Post-lesson interview at practice school, problem solving and strings, Dec 13)

In all the teaching sequences with Lorena at Pinehurst the students worked individually on the problems. Lorena did not encourage the students to collaborate. However, when teaching at the practice school, at the end of the methods course, she asked the students to turn and talk several times, showing shifts in the use of turn and talks to include student sensemaking.

Setting up a task. There was a noticeable shift in the way Lorena launched a problem. In her second enactment Lorena launched a problem for the first time, and she presented the problem to students in a clear way. However, she did not elicit students' ideas. During the team debrief of the enactment, the TE emphasised the importance of assessing students' understanding (interpretation) of the problem.

Lorena: He was having a little bit of trouble seeing the actual problem, so that is why I went to the manipulatives. And then he was able to get it with the 120, but then with the 180 we had to go step by step.

TE: Did you ask him to tell you the problem?
Lorena: No, I did not. I probably should have.
TE: Next time.
Lorena: Have him restate the problem to me.
TE: If you say he is having trouble with the problem then I want to know what it sounds like when he tries to tell you the problem. (Reflection after second enactment, problem solving, Oct 25, 4th class session)

As the methods course progressed Lorena became more confident during the launching phase and communicated more with students. But she continued to have difficulties with phrasing questions. The data show that she was aware of this issue; she was working very hard on getting better at formulating questions. However, according to herself, she was not very successful when working with strings at the practice school. Although phrasing questions to ask students was challenging for Lorena, she was able to invent new problems while she was teaching that were not planned and add these problems to the end of the lesson. This was an example of adaption and innovation.

Using representations. Lorena's use of representations grew over the term. In her first enactment, Lorena represented students' thinking on the board. Later in the methods course, she selected students with various representations to share their work. However, Lorena did not focus on the relations between the different representations. In her field placement, she presented various representations in a clear and structured way and she tried to facilitate students' understanding of how representations related to each other and the context. However, as mentioned earlier, Lorena had difficulties with using representations to promote students' understanding of the content goals of the string. Reaching the mathematical goal was not yet something she was confident in.

Summary. Lorena conveyed a sense of identification with the aims of teaching mathematics in a way that elicited students' thinking. However, she was not very confident in her knowledge of mathematics for teaching. At the end of the term, Lorena asked students to share their strategies, but she had difficulties supporting students to compare strategies. She also attended to the use of representations and was just beginning to help students attend to how different representations were related to each other.

Andrew

Andrew enacted an IA three times at Pinehurst in the following order: game, strings, and strings. Andrew also taught strings when we observed him in his own field placement and notably he posed the same string as the last one he used at Pinehurst. He told us he selected a task that he thought we would want to see.

Managing interactions with students. Over the methods course there was a change in the way Andrew elicited and responded to students' thinking. In his first enactment, Andrew asked the students to explain their strategies. However, he had difficulties finding good ways of asking the students about their thinking. Notice below the different phrasings he tries on as he moves to elicit a student's ideas.

Andrew: ...Can you explain to me, what did you throw, what digits did you use, what were you thinking when you, explain your brain to me. How did you figure that out? (First enactment, games, Oct 18, 3rd class session)

Like our other two participants at the beginning of the course, Andrew did not use follow-up probes to elicit student explanations or ask for students to notice mathematical connections. Typical questions Andrew asked: "Who would you like to come up and share"? and "Would you like to explain to us how you solved it"? The TE interjected during Andrew's teaching to illustrate how the teacher could encourage the students to elaborate on their strategies. Andrew took up these moves, not only when the intervention occurred but also in his subsequent teaching. Although Andrew asked students to share their thinking and elaborate on their strategies, he tended to take over and provide explanations. The inclination to insert teacher-produced explanations is a common response to wanting to make sure the mathematical ideas are conveyed in instruction.

During course rehearsals, Andrew did request support with how to elicit students' ideas. The TE and Allison tried to scaffold Andrew's development by suggesting ways of posing questions.

Andrew: And which, how, which is, eh, I don't know how to say that. How much is each of those worth?
TE: What are you asking?
Andrew: I'm kind of asking (points to the board)
Allison: What are you trying to get?
Andrew: 25 (points to the board)
Allison: We are just asking, "How many groups of 25 are there"? (Rehearsal before third enactment, strings, Nov 15, 7th class session)

The TE interjected many times during the enactment that took place after the rehearsal to illustrate possible moves the teacher could make to elicit students' thinking instead of providing explanations. These moves were partly used by Andrew when the interventions occurred.

At the end of the term, when he was teaching in his own field placement, Andrew posed questions and prompted turn and talk, asking "What did you draw and what were you thinking"? Moreover, Andrew monitored for and brought out students' ideas. He picked out students' drawings, but then he provided explanations of them. Andrew also modelled new strategies and provided explanations for the more cognitively demanding aspects of the activity. The students did not get the opportunity to work on these aspects/questions before Andrew provided an explanation. In the post-lesson interview, Andrew commented that one student that did not seem to be understanding that well might have been more successful with more direct instruction.

In all of the teaching sequences on video at Pinehurst, Andrew did not encourage the students to collaborate. The students worked individually on the problems. At the practice school Andrew used turn and talk one time at an appropriate time. He allowed for turn and talks more so than collaboration.

Setting up a task. There was a noticeable development in the way Andrew launched problems. At first, Andrew launched the problem in a clear way, and he communicated with the students to make sure they understood the problem. However, as with Allison, it was challenging for Andrew to launch the problem when working with a string that targeted the multiplication strategy of doubling and halving. The TE interjected during the rehearsal by suggesting possible ways of posing the problem to orient the students toward the relationship between the drawings.

Andrew: ...How do we make this 100 into a 50? Or I was just thinking about that. Or "How do we split this 100 into 50s"?
TE: Why don't you ask, "How do we change this 100 times 4 array into a 50 times 8 array"? Ask them what it would look like to do that. (Rehearsal before third enactment, strings, Nov 15, 7th class session)

Andrew did not immediately use these suggestions. Both the TE and Allison, who was teaching strings with Andrew, provided further suggestions. These moves were used by Andrew after a few examples had played out.

In this excerpt, Allison and Andrew are about to help students identify what happens to the product when one factor is halved and the other is doubled:

TE: Let us see what happens if we half and double again.

Allison:	So half of 50 is what? It is 25, right? And if we double 8 we have 16. So do we think we are going to get the same answer for 25 times 16?
All students:	Yes.
Allison:	Okay, can you do it on your paper? Can you be using that array that you drew?
TE:	Can you prove it?
Andrew:	Show us!
TE:	Prove it using that array. That picture.
Andrew:	How do we change this picture to solve the problem? (Third enactment, strings, Nov 15, 7th class session)

The question that Andrew posed at the end of this excerpt helped direct students to use the array model to explain the halving and doubling relationship. When Andrew was teaching the same string at the practice school, at the end of the methods course, the students did not get the opportunity to explore the relationship between the drawings. Instead, Andrew chose to model this relationship to the students. Therefore, he launched each problem separately.

Using Representations. There were small shifts in the way Andrew used representations. At first, he chose to use students' own drawings as a starting point for sharing strategies. The TE interjected during a rehearsal of a string to illustrate how the teacher could focus on the relation between different representations and thus orient the students toward important mathematical ideas. Andrew took up these moves in the subsequent teaching sequence. He used different kinds of representations to support students' thinking, and he also represented students' thinking on the board. In the reflection dialogue, he wanted to discuss how he could have used one of the models in a better way. This shows that he was aware of the importance of using representations. At the end of the methods course, when Andrew was teaching the same string at the practice school, he used the same kinds of representations but in a different way. Using the area model he provided explanations on how the arrays would change. The representations were used to support the teacher's explanation about important mathematical ideas.

He posed the problem (100 x 4 and then 50 x 8) and asked students about their representation.

Andrew:	So if we were to draw this, 100 times four, it would look something like this (draws and labels a rectangular array). And the inside is the same?
Student:	Mmm.
Andrew:	What do you notice about this picture then?
...	
Andrew:	What if we moved this? Cut it in half and moved it down here? (Draws on the board.) What would it look like? Would it look like this? (Point to the first drawing illustrating 50 times 8)
Student:	Yes
Andrew:	Probably (Teaching in field placement, strings, Dec 16)

In the post-lesson interview Andrew commented that he did not know if the student had learned the area model. He reported that the goal was for the student to learn doubling and halving, and he used the area model as illustration for students.

Summary. Although Andrew was confident in his knowledge of mathematics for teaching, he did not appear to identify strongly with the aims of ambitious teaching. He explained to us that he chose the lesson in his field placement based on what he thought *we* might want to see, conveying to us that although we identified with the forms of teaching that centred on student thinking, he was not completely appropriating that perspective. At the end of the method course he posed questions and asked students to share their thinking, but he tended to take over and provide explanations. Andrew attended to the use of representations and used different kinds of representations to support students' learning.

Discussion

The three PTs' experiences are situated within the learning opportunities afforded by the design of the course. It is tempting to attribute any shortcomings in the PTs' learning to them individually, but we think such a conclusion would miss the importance of understanding how the structuring of the course influenced what PTs did or did not appropriate. Close examination of three students' experiences illuminates what is possible in PTs' learning, what is challenging, and what needs to be made more explicit as we continue to refine and improve the design of practice-based methods (Ghousseini, 2013). Even as we look forward in the design of the course, looking back has allowed us to identify many challenges and possibilities. We suggest the three participants' development was supported not only by getting experience from teaching and taking part in reflective dialogues, but also by observing other PTs' teaching, observing TE's teaching, and TE's interjections during their own and their peer's teaching.

Course Design and Organisation

Our close analysis of three PTs raised a number of questions about different forms of participation. As we indicated when describing the course, the logistical orchestration of this course was complex. In the end, because of the way PTs took turns and our attempts in this particular year to coordinate the work of 30 PTs, we found that it was possible for PTs to have different opportunities to teach. Andrew had three opportunities to work with students, and he taught strings for two of the three times. Lorena did not have an opportunity to rehearse herself with teacher educator feedback (this issue has changed now that more teaching assistants and cooperating teachers have learned to lead rehearsals). The PTs also engaged differently. Allison was the most active verbal participant. Andrew participated mostly as a listener in reflective conversations.

Our observations suggest continued efforts are needed to work on the orchestration of the course so that PTs all teach the same number of IAs. We could make intentional use of protocols that enable students to participate more equitably in collective analysis. Certainly verbal participation is not the only way to contribute, but it is important for monitoring PT learning and identification with course principles, and for the teacher educator to have access to PTs' questions and responses to course experiences. At the same time that we develop how we work on teaching, we must also attend to whether PTs have equitable opportunities to participate.

Managing interactions with students.

Eliciting and responding to students' mathematical thinking so that mathematical ideas are advanced productively is at the heart of our work as teacher educators (Carpenter et al., 2014; Franke, Kazemi, Battey, 2007). We learned from our analysis that the design of the learning system appeared to support PTs to begin with eliciting how students solved the problem. Only one PT pursued questioning practices that requested students to develop mathematical justifications. This observation promotes several questions for future efforts. It is possible that the opportunities for reasoning and justifying ideas are not fully developed in the initial protocols for the instructional activities for the students. It is also possible that this type of instructional move is more sophisticated and warrants a stronger professional vision for how to steer mathematical conversations (Sleep, 2012). It is possible that the course is not making the mathematical goal clear enough to PTs to support the elicitation and development of mathematical justifications. PTs' own orientation and comfort with mathematical goals may also play a role (e.g., Maher & Muir, 2013). Several suggestions emerge from this observation: (1) ask PTs to state the mathematical goal and its import prior to the start of the rehearsal, and ask them to come to class having thought about the mathematical explanation that should emerge or be worked on during the enactment of the IA; (2) consider providing a mathematical goal for PTs; (3) during initial observations and study of instructional activities, make the mathematical goal and the nature of explanation elicited from students more explicitly visible and the subject of reflective conversation; (4) reflect on the use of talk moves not just to elicit students initial ideas but to build explanations and develop reasoning.

Using Representations

Both these and other analyses (Lampert et al., 2013) indicate that we worked on how to use representations in the context of the methods course as a public record of the mathematical ideas at play in the lesson. Beginning with representing students' thinking on the board was a common starting point for the three PTs. The use of representations to advance students' ideas is a complex task and our hope is that PTs would also learn to relate different representations to one another and to the mathematical story that unfolds during a lesson. In their initial enactments we did not see any of the PTs relating different representations to one another, perhaps because of our first finding that the enactments would benefit from clearer articulation of the mathematical goal. Our recommendations for improving the courses' emphasis on representations include more work on relating representations to one another and to the content goals.

Instructional Activities

Centring the learning of teaching practices around instructional activities has provided us a window into features of task design that make enactment more or less challenging to teach. The goal of the course was not just that PTs learn the five focal instructional activities. The goal was to use the specific instructional activities as a means to learn practices entailed in ambitious mathematics instruction. From other research, we know that the instructional activities place different demands on PTs in enacting teaching practices (Cunard, 2014). For example, learning to enact strings places particular emphasis on the use of representation as well as questioning practices that steer students towards mathematical goals in a particular way. Strings also demand a set of questioning practices that are predominantly about helping children make connections, articulate relationships and correspondences among and between representations. Choral counting demands that teachers make intentional selections and listen for the difference between describing and justification when students identify patterns and attempt to explain why they appear in the count. More analysis of the features of selected instructional activities and PTs' experience with them will support the continued refinement and development of the course design. It seems useful to consider the differential demands placed on PTs when selecting a suite of instructional activities for initial teacher preparation and for determining in what sequence to learn the instructional activities.

Identities and Knowledge for Teaching

The three PTs appeared to have developed different orientations to the principles of the course. Allison and Lorena conveyed a sense of identification with the aims of teaching mathematics in a way that elicited students' thinking. Allison was particularly confident in her knowledge of mathematics for teaching whereas Lorena shared hesitations about her level of knowledge of mathematics for teaching. Andrew, on the other hand, while feeling fairly confident in his knowledge did not appear to identify strongly with the course aims. He showed more willingness to adjust his teaching lessons moving towards or away from eliciting student thinking based on what might have been expected of him from external authorities such as the mathematics methods instructor, his university supervisor, or his mentor teacher. Our findings will remind readers of the large body of research that has investigated the relationship between beliefs and practice (e.g., Ernest, 1989; Philipp, 2007). While we prefer to broaden the notion of beliefs and cast ideas about beliefs in terms of stance and identity, our findings lead us to make the following recommendations: (1) We contend that developing one's teaching practices is not just a matter of developing technical skill. Teaching is value-laden work that requires both intellectual and emotional investments. The mathematics methods course is attempting to cultivate a particular stance and identity towards teaching, and PTs' responses to this stance is important in their learning. (2) As teacher educators, we must continue to wrestle with how to attend to the cultivation of identity at the same time as we work on technical skill and knowledge for teaching. Instructional strategies are useful when you know why you are using them. So knowledge of content and students matter in the productive execution of teaching strategies. The design of the course must continue to support PTs to learn about instructional practice in the context of learning and strengthen their mathematical knowledge for teaching.

Conclusion

This paper reported on PTs' learning experiences when participating in a methods course that was organised around a set of core practices of classroom teaching. Close examination of the PTs' experiences illustrated what instructional practices they began to use over the course of the methods course and what challenges they met. Their trajectories were different, and we attempted to interpret their developing practice in relation to the opportunities for learning afforded by the course. Their challenges also illuminate the ways we need to continue to develop teacher education practice, including more research on what and how PTs learn in practice-based teacher preparation courses.

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