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Developing the Practice of Teacher Questioning through a K-2 Elementary Mathematics Field Experience

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Abstract

This article presents findings from research on a field experience designed to help elementary preservice teachers learn the practice of teacher questioning during formal and informal interviews to analyze student mathematical thinking in K-2 classrooms. The practice of teacher questioning is framed as choosing a mathematical goal, analyzing student thinking about that goal, and then deciding on a question or prompt. Preservice teachers were specific and accurate in identifying a mathematical goal and analyzing student thinking when responding to a video-taped interview, but were less successful in their explicit discussion about the rationales for particular teacher questions in response to student thinking. More research is needed to understand tasks for preservice teachers in early field experiences that will help them develop intentional use of teacher questioning to facilitate student thinking about mathematics.

Introduction

Field experiences are a mainstay in traditional preservice teacher education (Darling-Hammond & Bransford, 2005). Preservice teachers report the time spent in classrooms during internships to be the most influential and useful part of their preparation programs (Guyton & McIntyhre, 2010). Recently mediated field experiences (Zeichner, 2010) have been powerful in helping preservice teachers make sense of what they are doing and seeing in the mathematics classroom. Concurrently, researchers have focused on the notion of high-leverage practices (Ball, Sleep, Boerst, & Bass, 2009).

Knowing that the complexity of teaching takes time to develop, high-leverage practices are those practices that are most essential to the work of teaching in terms of impact on students and that are most likely to be easily accessed by beginning teachers.

Planned revisions to an existing K-2 mathematics practicum created an opportunity to deliberately dovetail the notions of mediated field experiences and high leverage practices into a mathematics field experience. The field experience was re-designed around the practice of teacher questioning to see if the use of a mediated field experience could better support preservice teachers in their development of the practice than the existing field experience in which our preservice teachers went to their placements alone. More broadly, questioning is an important, yet complex teaching practice. Work with preservice teachers in developing the practice of questioning has yielded mixed results (Moyer & Milewicz, 2002; Ralph,1999a, 1999b; Weiland, Hudson, & Amador, 2013). The goal of this research was to contribute to our understanding of the ways in which preservice teachers do and do not take up the practice of questioning and how the structure of a field experience affects this development.

This study reports on data collected during the first pilot of the revised practicum. The preservice teachers in the revised and existing practicum were compared in terms of content knowledge and the practice of teacher questioning. I first describe the rationale for the choice of teacher questioning as a high-leverage practice and discuss the current literature on preservice teachers' use of questioning. Then I discuss the lens through which teacher questioning was viewed including a focus on mathematical goals, analyzing student thinking, and deciding on a teacher question or prompt in response to student thinking. Finally, I explain the differences between the two practica including the notion of a mediated field experience (Zeichner, 2010), and describe the differences in the ways preservice teachers in the two groups responded to an assessment of content knowledge and teacher questioning.

Teacher Questioning as a High-Leverage Practice

Teacher questioning was chosen as the high-leverage practice on which to focus for the revised practicum experience. Ball, et al. (2009) indicate criteria both for the work of mathematics teaching and for the teacher education context to be used when determining high-leverage practices for beginning teachers. In terms of the work of mathematics teaching, the practice must be central to the work of teaching and must help student achievement. The practice should be used frequently in teaching and be useful across teaching approaches. Teacher questioning fits these suggested criteria. Effective teacher questioning is widely acknowledged as an essential part of mathematics teaching (Carpenter, Fennema, Franke, Levi & Empson, 1999; Hufferd-Ackles, Fuson, & Sherin, 2004). In addition, teacher questioning is nested in other high-leverage practices like orchestrating whole class discussions (Smith & Stein, 2011).

A second set of criteria for determining a high-leverage practice focuses on the teacher education context (Ball, et al., 2009). Can the practice be taught to and practiced by beginning teachers in field-based settings? Is the practice accessible to learners of teaching and able to be revisited many times with increased sophistication? Evidence from research suggests that the practice of teacher questioning does need to be taught rather than assuming teaching experience alone will build competence. Preservice teachers are not intuitively competent at questioning (Ralph,1999a, 1999b). Jacobs, Lamb, Philipp, & Schappelle (2011) compared the responses of teachers to an interview of the kindergartner, Rex. The participants had different levels of experience in a professional development program focused on student thinking, primarily Cognitively Guided Instruction [CGI] (Carpenter, et al., 1999). They found no evidence that teaching experience alone enabled teachers to decide how to respond to students based on their understandings. Expertise grew the longer they had participated in the professional development. Furthermore, teachers who did attend to student thinking in their responses to the video performed at different levels on the scale that measured decisions about how to respond to the student. Attending to student thinking, then, is a pre-requisite for deciding how to respond. These different levels of performance, even after teachers are attending to student thinking, suggest that teacher questioning can be revisited at increased levels of sophistication.

While a case can be made for teacher questioning as a high-leverage practice, whether or not preservice teachers are able to become effective questioners during their teacher preparation is less clear. Ralph (1999a) found in a comparison of interns' self-analyses of lessons taught at week five and week 11 of a field experience that they reported a decrease in unclear questions and an increase in asking a variety of levels of questions. Moyer and Milewicz (2002) found that preservice teachers' experience interviewing students allowed them to recognize and reflect on effective questioning. However, they were still often falling back to instruction and *checklisting*—that is, asking questions with single answers in rapid succession-- rather than probing for student thinking.

In a case study, Weiland, et al. (2013) followed two preservice teachers across a semester as they worked together to conduct weekly assessment interviews, build models of student thinking, and teach whole class lessons. The preservice teachers decreased their use of nonspecific follow-up questions over the course of the semester and increased their use of competent follow-up questions, defined as questions where the preservice teacher attempted to build on student thinking. They suggest that preservice teachers can develop their questioning skills through rich field experiences, although they note that the preservice teachers needed continued development in not using leading questions and in capturing missed opportunities to probe student thinking further.

These mixed results about how preservice teachers take on the practice of teaching questioning raises the issue of readiness to completely develop such a complex part of the work of teaching at an early phase in teacher education. However, the significance of teacher questioning to the work of teaching and to student learning makes it important to try, particularly when preservice teachers often see the role of teaching questioning as simply a means to motivate students or get their attention (Cakmak, 2009). Understanding what the increasing levels of sophistication in teacher questioning might be as preservice teachers develop seems a productive area of research. The goal of this study was to use the opportunity to revise the practicum by designing a mediated field experience (Zeichner, 2010) to support preservice teachers questioning and subsequently to see in what ways they were and were not able to make progress. Mediated field experiences address the disconnect that often exists between university courses and school-based field experiences (Zeichner, 2010) by carefully planning the time in schools rather than leaving the clinical teacher and preservice teacher to work out assignments required by the university for themselves.

Framing Teacher Questioning

Teacher questioning does not happen in isolation from the other aspects of teaching. To ask a good question, a teacher must first know the mathematical goal of the lesson or assessment and listen to how the student is taking up the work of that mathematics. He/she then must decide what next question would be best to help understand more about how the student is thinking or move the student's thinking forward. To capture this process, the practice of teacher questioning for this project was articulated through the lens of the instructional triangle (See Figure 1); that is, through the interaction of the mathematics, the students, and the teacher within context to promote mathematics learning (Cohen, Raudenbush, & Ball, 2003; National Research Council [NRC], 2001).

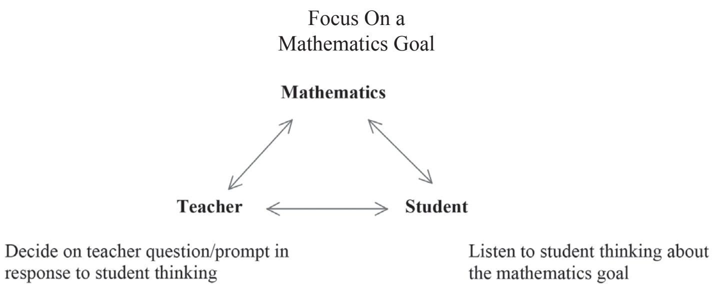

Figure 1: Teacher Questioning through the Lens of the Instructional Triangle (NRC, 2001)

Within this frame, the practice of teacher questioning was broken down into three components representing the parts of the instructional triangle: a) focusing on a mathematical goal (mathematics), b) attending to student thinking about the goal (students), and c) deciding on a teacher question or prompt in response to student thinking (teacher). The format and assignments for the revised practicum were designed to address these three components, while recognizing that they are intertwined and often happen simultaneously or in close succession to each other during instruction.

Determining a mathematical learning goal is an important first step in instruction and assessment of any mathematics skill or concept.

> Without explicit learning goals, it is difficult to know what counts as evidence of students' learning, how students' learning can be linked to particular instructional activities, and how to revise instruction to facilitate students' learning more effectively in future lessons. (Hiebert, Morris, Berk, & Jansen, 2007, p. 51)

In other words, you cannot analyze student thinking and ask an appropriate question in response without knowing the mathematics you are trying to teach or assess with a particular task. Competence in subject matter knowledge is essential to unpacking concepts and determining learning goals (Ma, 1999) because teachers must identify the mathematical subconcepts within the learning goal that a student must understand. Morris, Hiebert, and Spitzer (2009) found that preservice teachers could identify subconcepts of learning goals related to decimals and fractions in supportive contexts, those in which the subconcepts were obvious in the task or in a student's incorrect response. However, the preservice teachers did not identify subconcepts in non-supportive contexts in which they would have had to be intentional about the mathematics that their students should be doing to show understanding. Unpacking the mathematical learning goals and knowing the concepts that students need to understand is essential to knowing what question to ask next based on a student's thinking.

In this study, subject matter knowledge was primarily addressed in an integrated K-2 mathematics and methods course preservice teachers took concurrently with the practicum. This coursework was the same for participants in both the existing and revised practica so the working assumption going into the study was that the groups would show no difference in an assessment of content knowledge at the end of the study, but may show a difference in recognition of learning goals when analyzing a student interview.

The determination of learning goals and subject matter knowledge alone are not enough. Gearhart and Saxe (2004) emphasized the importance of teachers developing deep subject matter knowledge *and* attending to how students made sense of it. The second component of the practice of teacher questioning is attending to student thinking about the goal. Attending is more simply paying attention or being present, but noticing (Jacobs, et.al., 2011) student strategies and listening (Davis, 1996) to their thinking to come to a shared understanding. Much research has demonstrated the benefits of having teachers attend to student thinking in terms of teachers' increased focus on problem-solving, assessment of students, and student achievement (Carpenter & Fennema, 1992; Gearhart & Saxe, 2004). Furthermore, attending to student thinking is an essential piece of questioning (Jacobs, et al., 2011). When teachers attend to student thinking, they can then decide on a teacher question or prompt in response. Martino and Maher (1999) propose a link between understanding students' constructions and asking a timely question.

Even when focused on student thinking, teachers respond differently in terms of the questions they ask. Similar to the Jacobs, et al. (2011) study noted above, Franke, et al. (2009) found differences when examining the teacher questioning of three elementary teachers who were participants in professional development and who were all focused on student thinking. They readily asked students an initial question prompting them to explain their thinking, but they frequently followed up on those questions in different ways, either with a specific question, a general question, a probing sequence of questions, or a leading question. This finding indicates that although teachers may be asking similar questions, they are listening in different ways. Some engage in *evaluative listening,* that is, "an uncritical taking in of information" (Davis, 1996, p. 53) while others are listening interpretively to make sense of the student's ideas. In the Franke, et.al. (2009) study, the probing sequence of questions about a student's thinking was the most beneficial in enabling "the teacher to more fully understand student thinking and, therefore, to make more informed instructional decisions…." (p. 389).

To engage in the practice of teacher questioning, teachers must focus on a mathematical goal, attend to student thinking about the goal, and decide on a teacher question or prompt in response to student thinking. For this study, all activities, assignments, and assessments in the revised practicum were created with this framework in mind.

Methodology

Participants and Setting

The participants in this study were 56 preservice teachers, enrolled in two sections of a required three-hour grades K-2 mathematics and methods course taught in the beginning of an elementary teacher education program at a large state university in the United States. The course integrates mathematics content and methods with the focus primarily on number concepts and algebraic thinking. These topics included early counting, place value, addition and subtraction with CGI (Carpenter, et al., 1999) problem types, patterns and functions, understanding of equality, and relational thinking. Preservice teachers engaged in open-ended tasks to increase their own content knowledge of K-2 number and algebra and to experience problem-based mathematics learning. Debriefing of their learning experiences focused on use of mathematical practices, establishing classroom norms, task selection, teaching for conceptual understanding, and use of representations. In addition, preservice teachers focused on student thinking, learning trajectories, and assessment through analysis of student work.

The one-hour practicum which is the focus of this study was completed concurrently with the course. Participants were divided into the different practicum groups simply based on the section for which they registered. The existing practicum had 29 preservice teachers, and the revised practicum had 27 preservice teachers registered. They had no knowledge of the different practica experiences ahead of time. The two sections of the course were taught back-to-back by the same instructor on the same two days of the week. Preservice teachers in the two sections differed only in their completion of either the existing or revised practicum. They were exposed to the same material during the university coursework.

Existing Practicum

In the existing practicum, preservice teachers were placed in individual classrooms at multiple schools in multiple school districts. They were released for eight class sessions over four weeks to work in their practicum placement. They were sent to the placement with a list of assignments to be completed in their assigned classrooms. Individual student interviews were included in the list of assignments. Preservice teachers were to interview an elementary student eight times across the semester. Suggested activities were provided for the first four interactions based on grade level, and usually consisted of a single open-ended word problem for each session. Preservice teachers then decided on the content and tasks for the second four interactions.

Tasks, reflections, and student work were turned in at the end of the semester with the other required assignments including a teacher interview, teaching a game, mapping the classroom, and classroom observations. One reason for revising the practicum is that the student interviews, intended to help preservice teachers analyze student thinking often turned into tutoring sessions at the request of the classroom teacher. The focus often shifted from student thinking to teacher telling. Secondly, preservice teachers in the existing practicum did not receive feedback on their assignments throughout the semester, since they were all turned in as a portfolio at the end of the course.

Revised Practicum

Preservice teachers in the revised field experience were placed in one of three classrooms in a single school where they conducted structured interviews with K-2 students using Assessing Mathematics Concepts (AMC), a web-based interview assessment focused on early number sense (Richardson, 2011). Rather than be released from the mathematics methods course for four weeks as in the traditional practicum, the class continued to meet two times per week, once at the elementary school and once at the university.

Preservice teachers completed initial interviews with students using the AMC assessments. In the web-based version of these assessments, a prompt or question is provided for the teacher to present to the student, and then the teacher records both the answer the student gives and the strategy they used to find the answer. The software then uses that information to determine the next prompt. At the end of the interview students are given a leveled score for the student indicating whether the student is proficient at the concept or needs further practice or instruction. The university methods instructor was present during these interviews, and preservice teachers were able to request guidance during the initial interviews.

During the class session after the initial student interviews, preservice teachers worked collaboratively to analyze data and determine student groups. Each week, preservice teachers taught a small group of two or three students. Both the university supervisor and the classroom teacher were present and regularly gave real-time guidance and feedback. At the sessions of the methods course between teaching, preservice teachers met with others assigned to the same classroom to debrief and jointly plan the next lessons based on student work. Preservice teachers were asked to state their mathematical goal for the lesson, explain what specifically they were looking for as evidence of student thinking, and list preliminary questions they might ask with anticipated student responses. They submitted a written reflection after each lesson detailing their students' thinking and their own questioning. Finally, preservice teachers repeated the structured web-based interviews with students at the end of the semester and wrote a final paper about the entire field experience.

Zeichner (2010) describes several programs' attempts to cross the university-practitioner divide to improve field experiences for preservice teachers, especially in ways that undo the traditional hierarchical structure in which universities are the authoritative source of knowledge and the field experiences are simply places to practice. One such attempt, *mediated instruction*, occurs when university methods courses connect to the expertise of the teachers in field placements to "mediate the gaps between their campus courses and the students' school experiences (p. 94)."

The revised field experience attempted to mediate this gap in three ways. First, the experience was mediated by the instructor from the university methods course who went to the school with the preservice teachers providing support to preservice teachers during interviews and instruction when needed and sitting in on assessment and planning discussions between visits to the school. Secondly, the classroom teachers received classroom data from the interviews conducted. They commented on the subsequent groups formed by preservice teachers and provided support and feedback to preservice teachers during and after the small group lessons. The structured interviews were also mediated by the web-based software which prompted teachers with the "next question" based on the input they entered about how the student responded to the previous question.

Measures

Two measures were used for this study to examine differences between the existing and revised practica in the three components representing the parts of the instructional triangle. The first measured mathematics content knowledge through selected questions from the Mathematical Knowledge for Teaching (MKT) measures (Hill, Schilling, & Ball, 2004). The second measure was a video-based interview assessment created for the practicum in which preservice teachers analyzed an interview with a second grade student. Preservice teachers completed the MKT measures and the video-based interview assessment during the same week at the end of the semester. The MKT measures were used to determine if the groups differed significantly in content knowledge that was covered in the corresponding integrated mathematics and methods course indicating whether or not content knowledge might have been a factor in the preservice teachers' performance on the video-based assessment which focused more explicitly on the particular practice of teacher questioning. Because the participant selection was an un-prescribed convenience sample and the material covered was the same in both sections of the course, the assumption was that content knowledge would not be significantly different.

Twelve items from were selected from the Elementary Number and Operations forms of the test. Twenty-two questions were initially selected to match the content of the course, namely those topics in number sense that are typically taught in a grades K-2 classroom. These topics included whole number addition and subtraction, place value, equality, and patterns and functions. Then, because the MKT measures are designed for use with practicing teachers and the use in this study was with early preservice teachers, the 22 questions were narrowed to include only those with a difficulty level less than 0.555. The decision to limit the questions to topics covered in the course and those with lower difficulty was made in order to create a measure in which preservice teachers had a reasonable chance of being successful and which would be better able to detect differences if they were present. A two-sample t-test was conducted to compare the mean scores of each group. No difference between the mean scores was expected since both groups completed the same methods coursework.

The second measure was a video-based interview assessment. Preservice teachers watched a five minute interview of a second grade student, Amy, from a state-developed professional development video (NCDPI, 1997) (see Appendix 1 for interview transcript). The interview focused on the concept of tens and ones as noted by the title of the segment on the training video. This title slide was edited out of the video so that the preservice teachers would not have any preconceived notions about the interview. Preservice teachers watched the interview online and then responded in writing to three open-ended prompts that were created based on the instructional triangle:

1. What mathematical content is the teacher trying to assess? Explain how you know. (mathematics)
2. What does the student understand? What does the student not yet understand? Be specific. Use what Amy says and does in the video to support your claims. (students)
3. Discuss the teacher's questioning during the interview. Why did she ask particular questions when she did? (teacher)

The prompts were deliberately broad in an effort see what the preservice teachers in each class section noticed themselves rather than to focus them on just what teacher educators or experienced practicing teachers might think important. All identifiers were removed from the response before coding, including the practicum treatment group in which the preservice teachers were enrolled.

The first question was a measure of the participants' identification of the mathematics content being assessed. The second set of questions examined each participant's analysis of what the student in the video did and did not understand. Responses for these questions were coded for the mathematics concepts cited by the preservice teachers. Each response that noted a different concept was coded as a separate item. If one preservice teacher included both "tens and ones" and "cardinality" in a single response, these were coded as two separate items. After a comprehensive list of items was compiled, similar categories were condensed (Miles & Huberman, 1994). For example, a response that noted "grouping by tens" was included in the "tens and ones" category. The frequency of each code was counted separately for prompt one and both parts of prompt two.

Prompt three asked preservice teachers to discuss why the teacher asked particular questions when she did. Therefore, a domain analysis using *ra-*

tionale as the semantic relationship (Spradley, 1980) was conducted to find emerging themes. Starting with the phrase, "x is a reason for doing y," similar rationales were grouped together to look for patterns. Consider the following statement from a preservice teacher's response.

> *The teacher begins with asking if there are more than 10 cubes in front of her. I think that was her way of introducing to Amy that they would be working with groups of 10. I also think it was her way of assessing Amy to see if she knew what 10 cubes would look like.*

In this instance, the preservice teacher is noting that the interviewer wanted the student to think in tens. This rationale was expressed by several of the participants using varying questions from the interview as their evidence. No *a priori* codes were used for the analysis of prompt three. Instead, the

Table 1: Video-based Assessment Rationales for Teacher's Questioning

	Number of Responses	
Rationale	Revised	Existing
To see Amy's understanding/observe her math thinking	10	18
To see how Amy found the answer	3	3
To clarify an answer	2	0
To teach/guide Amy	3	9
To get Amy to think in tens and ones	9	1
To get Amy to think	7	1
To support Amy's motivation	6	7
Total	40	39

emergent rationales were determined through iterative cycles of coding and categorizing. For a list of final codes see Table 1.

Often the same question from the interview was used to support different rationales by different students. For example, preservice teachers cited the portion of the interview in which the teacher asks Amy to rotely count by tens with four different rationales: a) to see Amy's understanding or observe her mathematical thinking, b) to teach/guide Amy, c) to get Amy to think in tens and ones, and d) to support Amy's motivation. All of these explanations from preservice teachers are plausible, so no effort was made to judge responses as correct. Rather, the goal was to compare the responses from the two practica to look for patterns in the rationales cited.

Findings

Findings are divided into four categories: content knowledge, identifying mathematics being assessed, analysis of student thinking, and decision-making about teacher questioning.

Table 2: Content Knowledge Information

Group	N	Mean	Std. Error	DF	t-ratio	p-value*
Revised	27	1[illegible]15	0.349	54	0.66	0.508
Existing	29	11.138	0.337			

*p-value from two sided t-test that assumes equal variances

Content Knowledge

As anticipated, two-sample t-tests showed no difference on the MKT measure between the existing and revised practicum groups (p = 0.508, See Table 2). This finding was to be expected since both sections of participants completed the integrated mathematics and methods course with same instructor, same materials and tasks, in the same semester, on the same day.

Identifying Mathematics Being Assessed

Differences existed in the ways participants identified the mathematics they believed the teacher in the video was trying to assess. Preservice teachers in the revised practicum exhibited a narrowed focus. They had fewer responses overall (n=34) and those responses were in fewer categories. Almost all preservice teachers in the group identified tens and ones as a mathematical concept being addressed (n=25). Other concepts identified were unitizing (n= 3), and one-to-one correspondence (n=2). One participant each mentioned spatial relationships, counting, more/less, and multiplication/division.

Only 15 out of 29 preservice teachers in the existing practicum identified tens and ones as a concept being assessed. There were more responses overall (n=45) citing a wider range of concepts including addition/subtraction (n=6), counting (n=5), and unitizing (n=4). Cardinality and one-to-one correspondence were noted three times each; more/less and subitizing were mentioned two times each; and multiplication/division, estimation, and spatial relationships were each cited once. Many more preservice teachers cited multiple concepts being assessed as if they were listing everything a child would need to know to be successful or anything they had studied in relation to K-2 number sense in the methods course in effort to cover all the bases.

Certainly many of the concepts listed are necessary as prerequisite knowledge, and some were addressed in the follow-up questions as the student approached the task. Therefore, these responses are not incorrect in the sense that the teacher could and sometimes did assess them as part of the interview. However, the primary goal of the interview as noted by the title slide, the initial task presented, and much of the follow-up questioning was to assess knowledge of tens and ones. The fact that all of the preservice teachers in the revised practicum were able to identify tens and ones as a concept being assessed versus half the teachers in the existing practicum shows marked improvement.

Analysis of Student Thinking

For part one of the second prompt, which asked students to state what the student in the video understands, the existing practicum preservice teachers again offered up more responses (n=62) than those in the revised practicum (n=40). However, overall both groups were similar in terms of what they said the student understood. The explanation for the greater number of responses is that the participants in the existing practicum listed some concepts that the student did understand, but were much earlier number concepts (one-to-one correspondence and cardinality, for example). One difference was the number of participants in each group who thought that Amy understood the equivalence of one ten stick equaling ten single cubes. Six participants in the existing practicum claimed Amy understood this concept compared to only one student in the revised practicum.

In part two of the prompt, participants describe what the student does not understand. Interestingly, this is the only question in which the preservice teachers in the revised practicum had more responses (n=62) than those in the existing practicum (n=35). Approximately equal numbers of participants in both sections said that Amy did not yet understand addition and subtraction and place value. Almost double the number of participants in the revised practicum also noted (separately from place value) that Amy did not understand grouping by tens/unitizing/number relationships (17 revised versus 9 existing). Another striking finding was the difference in the number of preservice teachers who asserted that Amy did not yet fully understand comparing/equivalence (11 revised versus 3 existing). The evidence cited by preservice teachers in the revised practicum to support this claim was usually a portion of the interview in which Amy counts the number of cubes in a ten stick and then says that another ten stick of the same length has nine. In general, preservice teachers in the revised practicum cited more specific instances from the interview to support their claims for prompts one and two. However, this specificity did not carry over into the responses to prompt three about teacher questioning.

Decision-Making About Teacher Questioning

Both groups of preservice teachers were still unable to explicitly reason about and discuss teacher questioning that fosters student thinking. When asked to discuss the teacher's questioning in the video and to offer rationales for why the teacher asked particular questions when she did, there was no discernable difference in the responses between the existing and revised field experience groups. A few preservice teachers in both groups responded with specific evidence to explain possible rationales for the teacher's questioning. For example, one preservice teacher wrote,

> *She [the teacher] first asked the student what the best way to count the cubes was to figure out how many there were. I think she did this to see*

if the student knew how to count them, and if she would group them in any way or count them individually.

However, responses overall lacked such specificity in two ways. Some preservice teachers simply summarized the teacher's questioning without any analysis of the rationales.

She asked Amy if she wanted to snap the 36 blue cubes together to see how many tens and ones there would be. Amy didn't want to do it, so she asked her to count some cubes that were already snapped together. She asked Amy what would be the best way to count the snapped cubes that were in front of her. After Amy told her that there were 34 snapped cubes instead of 44, she asked her if she knew how to count by 10's.

Other preservice teachers reasoned only generally about the particular questions the interviewer asked. Consider the following example.

The teacher has asked certain questions because she wanted to see if Amy did understand the content of counting by ones and tens. She wanted to make sure that Amy was not guessing, but actually understood the reasoning behind it.

These general rationales were coded to again look for patterns. The number of responses coded in each practicum was similar (40 revised vs. 39 traditional), and the content of the responses was not different enough to make any claims about the groups as a whole (See Table 1).

Preservice teachers in both groups focused on summaries or general rationales for questioning rather than discussing specific reasons for particular questions at key moments.

Discussion

While there was no difference in content knowledge based on the LMT measures given at the end of the semester, preservice teachers in the revised practicum group performed better on some aspects of the video-based interviewed assessment. They were better able to determine the mathematics goal the interviewer was trying to assess and the content the student in the interview did and did not understand, indicating that the mediated field experience did make a difference. However, in terms of explaining the rationale behind the teacher's questioning, there was no noticeable difference between the groups. Both groups offered vague statements without much evidence to support their answers or without making explicit connections between the evidence offered and the claims made.

Some success can be claimed with just the improved focus on determining mathematical goals and analyzing student thinking. Teacher change often begins with a focus on student thinking (Carpenter, et al., 1999) so the fact that the preservice teachers were able to demonstrate a focus on the mathematical goal and student understanding of that goal is encouraging. One explanation might be that the success of preservice teachers in the revised practicum is simply a result of having feedback throughout the course rather than only at the end. While this was certainly a contributing factor, the way the experience was mediated by the structured interview software, methods instructor, and classroom teacher seemed to make a difference beyond just regular feedback.

The decision to use a highly structured interview in the revised practicum was not made lightly. The computerized interview assessment (Richardson, 2011) provided questions for the preservice teachers to ask students. They entered student answers and strategies into the computer and were given resulting scores based upon those entries. An initial concern was that the use of such a structured program would not allow participants to come to their own conclusions about student thinking and subsequently create their own "next questions."

The structured nature of the interviews actually offered a nice platform for discussion about what evidence is important in assessing students' early number sense. Research has clearly shown that novice teachers attend to different aspects of teaching than do experts (Berliner et al., 1988; Borko & Livingston, 1989). In several instances during the first formal interviews, the results produced by the computer assessment were different than what the preservice teachers expected. For example, in the Number Arrangements assessment, students are asked how many dots are on a card and then what kind of groups they can find within those dots. The goal of the assessment is to see if students can recognize parts of numbers and combine parts of numbers without counting all (Richardson, 2003). Preservice teachers were surprised when students would get a score indicating they still needed to work on the topic. They first claimed that the assessment didn't work because their students got all the answers "right" and still got a low score. When probing further during class discussions, it became clear that the students had indeed answered with the correct number of dots, but they had arrived at the answer by counting by ones. The answers students gave about the groups they saw were dutifully entered into the computer by the preservice teachers, but were largely ignored in terms of the general impression they had about the success of the student during the interview.

In this way, the computer assessment served as an "expert" view that provided guidance about what to notice and often created a discrepancy with the novice interpretation. The discrepancy then created space for discussions about what is important to notice about student thinking related to particular mathematics goals. The mediated nature of the field experience, where the university instructor was on-site with the preservice teachers in a single setting, allowed for these shared experiences in the community that could be discussed immediately. This discussion would not likely have occurred with the existing practicum in which students went to multiple classrooms alone and only reported back to the university instructor their varied interview experiences after the fact.

However, the three points on the instructional triangle (Cohen, et al., 2003; NRC, 2001) do not occur in isolation in the classroom. Teacher questions and prompts are inextricably intertwined with the content and with student thinking. Participants in both groups had a hard time identifying the teacher's rationale for asking particular questions during the video interview. One explanation is that while the structured interview was helpful in terms of noticing student thinking, it did not allow for enough practice for preservice teachers in creating their own questions and thinking about the rationales. Those in the revised practicum did have the opportunity, though, to do their own questioning during the small group lessons they taught as did the existing practicum students who were given only a problem or task to present to their students. Thus, flexible interviewing for the initial interview was not particularly instructive either in terms of performance on question three of the video interview assessment.

Finding a way for beginning preservice teachers to make sense of the complexity of teaching and to progress with teacher questioning in relation to content and student thinking seems imperative. First, more research is needed on what tasks can be given in early field experiences to encourage preservice teachers to use what they know about the mathematics and student thinking to ask purposeful "next questions." Secondly, we need to understand how preservice teachers make sense of those tasks for their own practice.

Thirdly, we need more investigation into measures to assess the practice of teacher questioning. The video interview assessment is one such attempt. The assessment was successful in highlighting differences in determining a mathematics goal and what a student does or does not understand about a concept. However, more attention is needed to the question about teacher rationales for particular questions. Knowing how practicing teachers and mathematics teacher educators would respond to the same question would provide insight in what a reasonable performance would be for preservice teachers. Finally, it may not follow that a preservice teacher who can analyze a teacher's questioning on a video-taped interview can conduct such an interview in their own practice. Yet, in large teacher education programs where hundreds of students are completing a practicum in any given semester, watching and assessing a short video of the preservice teachers' actual teaching is daunting at best and unmanageable at worst.

While more articulation is needed about what is entailed in the practice of teacher questioning, this pilot study demonstrated that a mediated field experience (Zeichner, 2010) focused on teacher questioning did result in preservice teachers' improved competence in recognizing mathematical goals and student thinking. Both the tasks required in early field experiences and the measures used to assess preservice teachers' intentional use of teacher questioning to facilitate student thinking about mathematics need to be revisited.

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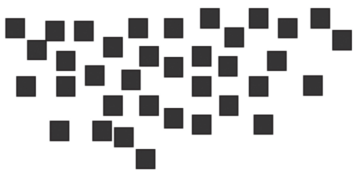
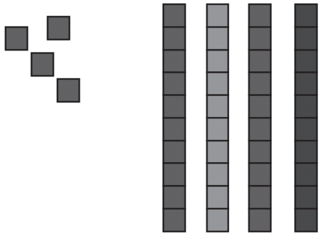
Appendix 1

Transcript of Video-taped Interview
The teacher has placed 36 cubes on the table and asked Amy how many there are.



Teacher (T): More than 10?
Amy is silent. Her eyes are moving around the table looking at the cubes.
Amy (A): 32
T: Did you count them with your eyes, Amy?
Amy nods yes.
T: It's okay to guess. If you think there are 32, how could we find out for sure?
A: To count them with our hands.
T: Would you do that?
Amy counts the cubes one-by-one out loud, moving each cube across the table as she counts.
A: 36
T: Amy, if you snapped them together to make tens and ones, how many do you think you would have?
Amy pauses for a moment. Then, she takes a deep breath and shrugs her shoulders.
A: That's hard.
T: There are 36 when they are loose like this (*scattering the cubes around the table*), if you snap then into tens and ones, how many do you think there might be?
A: Six tens and three ones.
T: Why don't you try it? Would you like to try it?
Amy shakes her head no.
T: So you don't want to try snapping them together and see.
Amy shakes her head no.
A: I don't want to.
T: You don't want to. Alright, that's fine. You don't have to. Would you like to count some other cubes for me?
Amy shakes her head yes.

The teacher pulls a new set of cubes out of her bag. Four sets of ten snapped together and three ones.



T: Amy, can you tell us how many cubes there are?
A: In all? *Amy waves her hand over all the cubes.*
Teacher nods.
T: Count out loud so I can hear you, okay?
A: Do I count all of these cubes? *Amy moves her fingers over the ten sticks.*
T: What would be the best way to count them? What way would you like to count them?

Amy shrugs her shoulders.
T: Why don't you count one of the sticks, and tell how many are in one of the sticks
Amy grabs one of the sticks.
A: Ten
T: Ten? You better check.
Amy takes one of the sticks (black) and counts to herself. When she is finished counting all ten she nods her head in agreement with her answer.
T: Is it ten?
Amy nods yes.
T: How about the other sticks, do they all have ten?
Amy pauses for a moment, after looking over the other sticks shakes her head no.
T: How can you find out?
A: Count them.
T: Is there any other way to find out?
Amy pauses.
T: You may count it if you'd like to.
A: I think it's nine. T: You think its nine, check and see.
Amy checks the red stick, she shakes her head no.
A: Ten.
T: Okay. How about the blue stick?
Amy takes the blue stick and places it next the red stick.
A: Ten.
T: Okay.
Amy takes the last red stick and places it next to the blue stick.
Amy: Ten.

T: Good. Alright let's go back to the first question. How many counters are there? How many Unifix cubes are there?

Amy places her hands over just the individual cubes.

A: These?

T: All of them together.

Amy looks at the cubes. She looks up and sideways, and then shrugs her shoulders. She looks at the cubes again moving her eyes along the sticks as if counting in her head.

A: Thirty-four?

T: Thirty four, alright good. I'm going to set these out of the way. I want you to do something for me.

Teacher moves the unfix cubes.

T: I'll move these out of the way. Do you know how to count by tens?

Amy nods here head yes.

T: Okay, say it for me.

A: Ten. Twenty. Thirty. Forty. Fifty. Sixty. Seventy. Eighty. Ninety. A hundred.

T: Very nice. Good okay.

The teacher places one stick of ten cubes in front of Amy.

A: Ten.

The teacher adds another stick of ten.

A: Twenty.

The teacher adds another stick of ten.

A: Thirty.

The teacher begins to add unfix cubes one at a time in front of Amy as she counts.

A: Thirty-one. Thirty-two. Thirty-three. Thirty-four.

The teacher adds a ten stick.

T: Alright, if I gave you ten more, how many will you have?

A: *Amy begins counting to herself (out loud).* Ten. Twenty. Thirty. Forty. Forty-four.

T: Very nice. Suppose I take one away, how many will you have?

The teacher takes away a single cube. Amy takes some time to think.

A: Forty-two.

T: Forty-two?

A: *Amy smiles.* Forty-three.

The teacher takes a stick of ten cubes away.

T: Suppose I take ten away, how many will you have?

Amy whispers 10, 20, 30, 31, 32, 33, then speaks aloud.

A: Thirty-three.

T: How about if I take ten more away? *The takes removes another stick of ten cubes. There are two ten sticks and three ones left.*

Amy is counting to herself in a whisper, 30, 40, 50. Amy responds out loud.

A: Fifty.

T: How many?

A: Fifty.

T: Okay.