Preservice Elementary Teachers' Early Practice of Eliciting and Responding to Students' Mathematical Thinking

by

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DEDICATION

For Lynn Sherman

My first and favorite teacher

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I have always been curious about other peoples' thinking and learning, so it is no surprise that this dissertation is in large part about student thinking and teacher learning. The production of this dissertation would not have been possible without the many individuals in my life whose support, guidance, and encouragement have provoked my thinking and supported my own teaching and learning.

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ABSTRACT

Learning to teach involves making a shift from layperson to teaching professional over the course of formal preparation. This shift requires putting aside naïve perceptions of self and teaching in favor of an informed conception of the professional teacher focused on others' — that is, students' — thinking and understanding.

Although many practices are central to the work of teaching, the practice of eliciting and responding to student thinking is crucial for teachers to gain insight into their students' ideas and ways of thinking. This dissertation investigated novice teachers' practice of eliciting and responding to student thinking at the beginning of their formal teacher preparation. Based on analysis of 27 preservice teachers' mathematics discussions during their first four weeks of preparation, the study analyzed the kinds of initial eliciting questions that the preservice teachers posed, and the kinds of responses they gave to students' contributions. The analyses showed that although preservice teachers had some skill in eliciting student thinking they were inconsistent in the methods of eliciting they used across teaching episodes. When responding to students, preservice teachers in this study often used guiding prompts even after students provided correct answers.

Results from this study offer insights into specific aspects of eliciting and interpreting student thinking with which beginning teachers might need support in order to attend to student thinking. Some of the findings also signaled that there may be tendencies that preservice teachers need to unlearn as part of their preparation in order to become skilled at eliciting and responding

to student thinking. The analysis of early eliciting and responding to student thinking practice can inform how teacher educators look at, talk about, and evaluate preservice teachers' practice.

Chapter 1

INTRODUCTION

Like many beginning teachers, I went into teaching because I liked being in school. I liked explaining things and I liked helping people. This focus on myself meant that at the beginning of my preparation to become an elementary classroom teacher I thought about what I was saying and how I was thinking, rather than being oriented towards my students. I doubt I was unusual in this way; many of my experiences with beginning teacher education students suggest that this might be a typical pattern. In fact, Lortie (1975) writes explicitly about what tends to attract people to the profession, and identifies the same “attractors to teaching” that drew me in (p. 27). But the “attractors to teaching” that Lortie names do not a skilled teacher make. How then does teacher education support individuals to make the transition from everyday practices of teaching to professional level practice (Cohen, 2013; Feiman-Nemser, 1986)?

One of the most important insights I had was that as a teacher you are supposed to be oriented toward what your students are thinking and doing. This conception of teaching had never occurred to me because in my own schooling I — as a student — was always trying to align myself with my teachers. I had great success in doing this as a student; I received accolades for thinking like my teachers and for doing what my teachers modeled at the board in the front of the room. In my first mathematics methods course I was astonished to find that there was more than one “right way” to add numbers together. In fact, I could actually ask my students how they were thinking about adding numbers together; they didn’t have to use the traditional algorithm to get the “right” answer to be correct.

With this epiphany and my new-found orientation toward student thinking, my teaching practice very quickly became focused on finding out what my third grade students were thinking and doing. This orientation toward my students transformed my role as the teacher. I now found myself responding to my students' thinking and work, rather than measuring how my students were matching my work, my thinking, my actions and me. A switch was flipped and I was more attuned to what my students were thinking than what I was thinking. This realization made me wonder, if I entered my teacher preparation program with these ideas about what teaching was and looked like, what do my preservice teachers bring to the table as learners and as teachers? How might I investigate this?

I began my investigation by looking at literature related to the prior knowledge and conceptions that students bring to learning. In reading Ball's (1988) dissertation I noted that she asked the very same question, "What does it mean for a learner to "bring" something to a situation? (Ball, 1988, p. 16)." She describes the use of the word "bring" as, "a metaphor… [which] conveys the idea that learners do not arrive empty-handed (or empty-headed), but that they come instead with ideas, understandings, ways of thinking, inclinations, and habits" (p. 16). I found many examples of research that unpacked the prior knowledge K-12 students bring to schooling and learning, and detail the ways this knowledge influences how students process and make sense of new ideas and learning (e.g., Anderson, 1984; Confrey, 1987; Davis, 1983; diSessa, 1982; Posner, Strike, Hewson, and Gertzog, 1982; Roth, 1985; Schoenfeld, 1983).

In reviewing this literature, I realized preservice teachers bring notions of schooling and ways of learning that are different from those of K-12 children. Unlike my elementary students, these college students had already experienced 12 plus years of schooling; they were bringing these schooling experiences and ideas to their own preparation. These preservice teachers had watched 13 grades of teachers teaching and had experienced learning as a student for all of this time. Thus it is logical that they would have many preconceptions in place about what it means to be in school and to teach. Lortie (1975) makes a sociological argument explaining how individuals vast experience in school as a student serves as an apprenticeship of observation which they may take as socialization into the profession of teaching. Lortie contends:

> "One often overlooks the ways general schooling prepared people for work. Such an oversight is especially serious with public school teachers, for participation in school has special occupational effect on those who do move to the other side of the desk. There are ways in which being a student is like serving an apprenticeship in teaching; students have protracted face-to-face and consequential interactions with established teachers" (p. 61)

He further argues that this view of learning to teach is problematic. An apprenticeship of observation in teaching as a student does not adequately prepare an individual to "move to the other side of the desk" and carry out skillful instruction. Ball (1988) builds on Lortie's work making an argument based more on advances in cognitive theory in the early 1980s. She remarks about prospective teachers:

> Thinking that they already know a lot about teaching based on their experiences in schools and on their good common sense, prospective teachers may not be disposed to inquire or to learn about teaching mathematics. Furthermore, and equally serious, what we know about what students learn in ordinary mathematics classes suggests that prospective teachers are unlikely to know math in the ways that they will need to in order to teach. (Ball, 1998, p. 13-14)

Thus, preservice teachers' own schooling has not adequately prepared them for the work of becoming a teacher. Knowing this, we, as teacher educators, must tailor instruction in teacher preparation to address and remediate these conceptions of and orientations towards schooling, student learning and teaching.

Knowing what preservice teachers know and tailoring instruction to meet these funds of knowledge is a large task, one that cannot be fully taken up by any single dissertation. So it became important for me, as a researcher, to narrow the scope of my investigation. I did so by choosing one practice, *eliciting and responding to student thinking*, as the focus of my dissertation research. I purposefully chose this practice for three reasons: (1) eliciting and responding to student thinking is deemed high-leverage by prominent researchers and research literature, (2) the work of eliciting and responding to student thinking requires an orientation toward student thinking which represents a shift in perspective from one's own thinking to the thinking of others, which is both foundational and necessary for skilled teaching, and (3) the practice of eliciting and responding to student thinking is of special interest to me since it is the practice through which I had my teaching epiphany. In the following sections I will elaborate on these three reasons, unpacking my choice and thinking around the practice of eliciting and responding to student thinking as the focus of this dissertation.

A High-leverage Practice

In skilled teaching many practices come to mind as central, core or high-leverage (Ball & Forzani, 2009; Grossman, Hammerness & McDonald, 2009; Teacher Education Initiative, 2009). High-leverage practices are those "tasks and activities that are essential for skillful beginning teachers to understand, take responsibility for, and be prepared to carry out in order to enact their core instructional responsibilities" (Ball & Forzani, 2009, p. 504). One high-leverage practice, in particular, requires orientation toward student thinking. This practice is eliciting and responding to student thinking. Eliciting and responding to student thinking involves: (1) posing questions or tasks that allow students to share their thinking, (2) evaluating students' specific understanding of content and concepts, and (3) surfacing ideas that will benefit other students while focusing the discussion on important content (TeachingWorks, 2015).

Orientation Towards Others' Thinking

At its core, eliciting and responding to student thinking is really all about how students are understanding and conceptualizing content. This focus on student thinking occurs because the work of the practice is to draw out and engage with students' thinking. In fact, the teacher is developing responses that are in relation to students' thinking. This disposition toward someone else's thinking constitutes a shift, where the student's thinking begins to take priority over the thinking of the teacher.

Flipping the Switch: A Teaching Epiphany

As a student, which is how many people experience school prior to entering teacher preparation, you are focused acutely on their own thinking and understanding. However, when you become a teacher, it is necessary to put aside your own thinking in order to focus in on others' thinking and understandings. Lortie (1975) suggests that, "beginning teachers undergo training experiences which offset their individualistic and traditional experiences" to facilitate this change in orientation towards student thinking. I am calling this change, from considering your own ideas to considering the thinking of your students, a switch. I do so to illustrate the shift in position from being a student to being a teacher, much like the change in position of a light switch from the *on* position to the *off* position. In this metaphor, I see preservice teachers enter teacher preparation with their switch in the *off* position. They bring conceptions about schooling from the view of a student, who is focused on his or her own thinking and learning. During their preparation it is necessary that they flip the switch to the *on* position, putting aside their own thinking and illuminating the thinking and conceptions of others.

The need for this shift occurs in part because formal schooling does not well prepare individuals to become teachers. Students are rightly focused on their own thinking and learning, given incentives and penalties based on how well they demonstrate their own knowledge. So then, why doesn't teacher preparation support a shift away from what is so ingrained in those who have participated in schooling as students? Feiman-Nemser (1983) suggests that the fault may be in the fact that, "formal training does not mark a separation between the perceptions of naive laypersons and the informed judgments of professionals" (p. 153). Instead, we, as teacher educators need a way to mark or support this change from thinking as a student or layperson to thinking as a teacher or professional.

One practice, that at its core, requires teachers to engage with their students' thinking is eliciting and responding to student thinking. If our work, as teacher educators, is to support preservice teachers in flipping the switch to engaging with student thinking, then it follows that knowing how pre-service teachers engage with student thinking, through the practice of eliciting and responding to student thinking early on in their preparation, is both informative and necessary for their development as skilled teachers.

The Problem

As teacher educators, we prepare our preservice teachers for a year, maybe more, maybe less. Within that time frame, we are expected to prepare skillful teachers who at the end of preparation, are well prepared to enter into classrooms and enact instruction with students. Knowing that skillful teaching is our goal, it makes good sense to know what our preservice teachers are capable of and what they are struggling with early on in their preparation. In knowing pre-service teachers' capabilities and struggles early on in the preparation program, we have time to intervene with support to improve teaching practice before candidates exit the program, gain certification, and go off into classrooms. Finding out at the very end of preparation that a teacher candidate is struggling does not leave any time for teacher educators to intervene and support positive change. We, as teacher educators need to know what our preservice teachers bring to their teacher preparation. We need to learn about their early practice, and not wait until our preservice teachers are half way, or all the way, through their preparation program to find out what they know, how they know it, and how this influences their teaching practice. In particular, I am interested in how preservice teachers engage in the practice of eliciting and responding to student thinking. I am curious about how well-oriented, or less well-oriented, preservice teachers are to the thinking of their students.

Although the research on teacher knowledge, teacher practice and teacher learning describes how in-service teachers engage in the practice of eliciting and responding to student thinking, very little literature delves into the practice of pre-service teachers and what it looks like to <u>learn</u> to do the practice of eliciting and responding to student thinking. The major problem my research addresses is the fact that we, as teacher educators, have little insight into how beginning teachers use questions to elicit and respond to student thinking at the beginning of their professional training.

Study Design

To address this problem, this dissertation aims to further the field's understanding of the practice of eliciting and responding to student thinking that novices engage in while learning this practice. Focusing on one mathematics teaching practice, *eliciting and responding to student thinking*, this study considers how a cohort of 27 preservice teachers (called interns) elicit and respond to their third grade students' thinking during mathematical discussions which took place during their third week of preparation. Use of qualitative methodology allows for close analysis of how novices learn and begin enacting this practice. I frame this dissertation with the following analytic question:

What does the practice of eliciting and responding to student thinking look like as it is being learned by preservice teachers during elementary mathematics instruction?

Specifically, I want to uncover and describe patterns of novices' practice of eliciting and responding to student thinking in elementary mathematics instruction. I do this by noticing and analyzing, for the preservice teachers in my sample:

(1) the kinds of initial eliciting questions novices seem to pose, and

(2) the kinds of responses to student answers novices seem to give.

Contributions of Study

Teacher education must prepare teachers with the knowledge and skills to enact high-quality instruction in support of the learning of all of their students. Knowing about student thinking is an essential component of this work, and the practice of eliciting and responding to student thinking reflects the necessary orientation towards student thinking and learning. In order to better understand the kinds of understanding pre-service teachers bring to preparation and to support a switch in orientation from self to student, I investigate the early eliciting and responding to student thinking practice of preservice teachers during the third week of their preparation.

The major contribution of this study is a much-needed description and categorization of the kinds of initial elicitations and responses preservice teachers typically employ to promote student thinking and learning during mathematical discussions. The categorization of eliciting and responding to student thinking developed in this study will inform teacher education, as well as research on teaching and teacher education, about the early practice of eliciting and responding to student thinking. This picture of eliciting and responding to student thinking will provide teacher educators with common language and descriptions that can be shared and used across preparation programs and institutions of higher education. Further, the descriptions provided here may be used to tailor instruction early on in the preparation program to support preservice teachers' practice of eliciting and responding to student thinking.

Organization of the Dissertation

The dissertation is organized into six chapters. Chapter 1, the current chapter, frames the research problem, provides an overview of the study, and outlines this dissertation. Chapter 2 reviews the literature from education, mathematics and linguistics that is relevant to the work of learning to elicit and respond to students' thinking. Chapter 3 describes the data sources and methods of analysis I used. Chapters 4 and 5 present the results of my analysis: Chapter 4 addresses the analysis of initial elicitations of the interns in this cohort, while Chapter 5 addresses the analysis of their third turn elicitations. Chapter 6 considers the implications of the study and directions for future research.

Chapter 2

LITERATURE REVIEW

Introduction

From the outside, the work of teaching may appear to be a routine of asking and answering questions; however, teachers must pose questions with purpose. That purpose is to better understand students' thinking, and support students' learning. The work of asking, or posing questions in classrooms is not a simple task. The ability to skillfully use questions to uncover student thinking and then interpret this thinking is a skill that is not innate, but learned (Ball & Forzani, 2009). In fact, the work of learning to use questions purposefully in teaching marks a switch from the everyday ways in which individuals ask and answer questions to the more specialized questions used in the profession of teaching (Lortie, 1975; Feiman-Nemser, 1983). Given the need for skillful eliciting, or question-asking, in instructional settings, teacher preparation programs increasingly recognize eliciting and responding to student thinking as a core, or high-leverage practice in the discipline (Grossman, & McDonald, 2008; Hatch & Grossman, 2009; Lampert, 2009; Shaughnessy & Boerst, in review; and Sleep et al., 2007). Preparation programs that strive to prepare beginning teachers for their careers must include explicit instruction in the practice of eliciting and responding to student thinking. While the instruction and practice of eliciting and responding to student thinking is becoming more common in teacher preparation there is no generally accepted description of what this practice should look like for beginning teachers. There is, however, consensus that beginning teachers need to be able to ask purposeful questions during the course of instruction. Teacher educators also know that they must teach beginning teachers to ask planful questions. How might reasonable entry-level practice in eliciting and responding to student thinking be defined and described? Borko (2004) and Lampert (1990) have defined what good eliciting and responding to student thinking practice looks like in practicing and experienced teachers, but there appears to be sparse literature that describes the features and content of beginning teachers' eliciting and responding to student thinking.

In order to better understand and describe beginning teachers' eliciting and responding to student thinking practice, I review the literature in three large sections: (1) questions, (2) student thinking, and (3) eliciting. I choose to organize in this way because I see using questions for the purpose of getting at student thinking as the manifestation of the practice of eliciting and responding to student thinking. Therefore I will begin with questions and present research on how questions are used in everyday life as well as in traditional and reform-oriented classrooms. Next I will describe a shift in mathematics education that has led to a focus on student thinking, and detail some of the research literature that aims to understand student thinking and teacher practice around student thinking. I will explore some theoretical frameworks for thinking about the work of engaging with and attending to student thinking during teaching. Then I will review specific literature on the work of eliciting and the practice of eliciting and responding to student thinking as it has been enacted in elementary classrooms. I will end with a summary of this review and present the research questions that guide this dissertation study.

Questions

Questions are used in everyday life to gain knowledge or to convey interest in another person's thinking. Questions have multiple purposes. They can be used to ask for information or to make casual conversation. Some questions are used rhetorically, to make a point, and are not intended to be answered. Other questions require an answer that is descriptive in nature, seeking an explanation for particular events, processes or phenomena (Mehan, 1979). Further, questions can be used to relate or connect ideas, people and events (Francis & Hunston, 1992). Yet while people use questions for many and multiple purposes, questions used in classrooms have historically taken on an entirely unique set of purposes (Erdogan & Campbell, 2008). In classrooms, teachers use questions to find out what students know, to probe thinking and to create new knowledge (Franke et al., 2009). Further, the kind of questioning that occurs in classrooms typically follows a specific pattern of initiate-response-evaluate, commonly referred to as IRE (Mehan, 1979). Therefore, while commonly occurring in everyday life, questions take on a distinctly different role in classrooms. Recognizing this difference requires a deeper understanding of the ways in which questions in classrooms differ from those in everyday life. To provide some context for this notion, I will review the literature on the role of questions as they are used in classrooms in the next section.

At the beginning of the twentieth century, Stevens (1912) stated that approximately eighty percent of a teacher's school day was spent posing questions to students. More contemporary research by Leven & Long (1981) on teacher questioning showed little change from the early 1900's, finding that classroom teachers posed between 300 and 400 questions each day. While the greatest majority of a teacher's instructional time is spent asking students questions, there remains a debate across social science fields as to the quality and purpose of questions posed to students in classrooms (Dillon, 1982, Feldhusen & Treffinger, 1980; Savage, 2010). For years, teachers have used questioning in classrooms to transfer factual knowledge and conceptual understanding. Although the act of asking questions has the potential to facilitate student thinking and learning, it also has the capacity to dissuade students from learning, if questions are perceived as an interrogation and not informational. So the question remains: what types of questions and questioning behaviors facilitate the learning process and what types of questions are ineffective? (Brualdi, 1998). Before answering this question, I turn to Mehan, who spent much of his career empirically investigating classroom interactions and talk. His research on the initiation-reply-evaluation, or IRE model represents the prototypical structure of talk in traditional classrooms.

IRE. In Mehan's (1979) "three-part initiation-reply-evaluation sequence" he considers two coupled pairs of turns of talk. The first, initiation-reply refers to the interaction between the teacher and the student around the teacher's initial question. The second, reply-evaluation, names the interaction between the teacher and student around the answer given by the student (p. 52)." Figure 2-1 below, gives a visual for these two pairs of talk that make up the three part sequence.

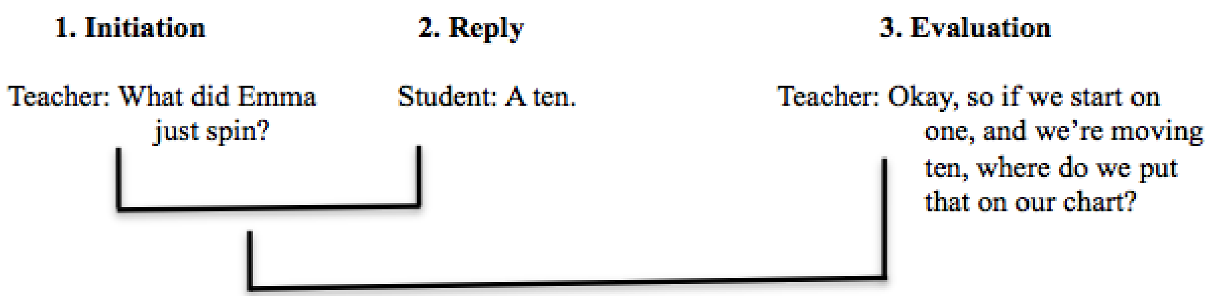

Figure 2-1: IRE Model

Important in this mode, is the teacher talk. In the two turns of talk the teacher provides a request for information with the expectation of eliciting a reply from the student. In the third turn of talk the teacher uses what has been given in the reply, the second turn, to form a follow-up evaluation. Both pairs are highly directed and dependent on the teacher. The student's role is to correctly respond to the verbal and nonverbal cues of the teacher to produce the expected reply. Rather than seeking new information, the teacher's questions in this sequence elicit known information, with the expectation that the student will "spit back" what is already known or has already been told by the teacher.

Research on spoken discourse has investigated the difference between "information seeking" questions and "known information" or test questions (Searle, 1969; Labov & Fanschel, 1977; Shuy & Griffin 1978; Levin, 1978). The former puts the burden of knowledge on the individual answering the question. The answer is not predetermined, as with known information questions. The initiator of the information seeking question is not testing the answerer's knowledge, but rather looking to fill in a gap in her or his own knowledge base. The known information questions are most commonly used in teaching and instruction. The teacher, or bearer of knowledge, asks a question about knowledge to ascertain if the student, or answerer, knows the same information. These questions are in fact examinations of student knowledge. This structure of discourse where the teacher asks and the student answers and is then evaluated, displays what Wood (1998) calls "*hidden regularities"* that guide the actions of both teachers and students in the classrooms. They are hidden and become the taken-for-granted way of interacting that constitute the culture of the classroom. Because the teacher has expectations for what constitutes a correct answer, only the teacher's expected answer will be accepted. If the student provides an unacceptable answer, the teacher asks another question to elicit the intended answer. In classrooms this exchange may take the form of a visual or verbal cue for other students to provide the correct answer, or the teacher might repeat or rephrase the question. Either way, it would look like an evaluative response of "no" to the student. Mehan (1979) describes this set of interactions as "searching" for a correct answer, which often leads to students responding with some form of imitation rather than knowledge (p. 291). Imitation is in fact common in classrooms (Mehan, 1979). As students go through schooling their responses to teacher questions may appear to reveal higher order thinking. Instead they have not acquired content knowledge, but have rather acquired the ability to follow and mimic patterns of classroom discourse. This is a troubling revelation for teachers and teaching. If instruction is not leading to student learning then it is not fulfilling its ultimate purpose nor serving students. Instead of forcing students to imitate, teachers must strive to understand students' thinking and use this thinking to support learning. Doing so requires a shift on the part of teachers in orienting themselves to the thinking of their students. The practice of eliciting and responding to student thinking is one practice that supports this shift, as it requires teachers to be attuned to student thinking.

Although classroom discourse has the potential to provide fertile terrain for teachers to access student thinking and learning, Lundgren (1977) found that many classroom interactions between student and teachers give the, "illusion that learning is actually occurring" when in fact the teacher is focused on evaluating the correctness of students' responses instead of eliciting students' true thinking (p. 202). Indeed, Wood (1998) describes funneling, a discourse practice where a teacher leads a student through a series of "explicit questions until the correct answer is obtained, as illustrated in the example, "What do you get when you add the 4 to the 10? Eleven, twelve, thirteen…?" In funneling cases like this one, students are merely filling in the blanks to responses teachers have already constructed. Instead of displaying their knowledge of content, students are actually revealing their knowledge of classroom discourse practice by following the lead of the teacher. What looks like communication of knowledge is in reality, communication of knowing how to behave in teacher-student discussions. Instead, I make the case for skilled eliciting and responding to student thinking. Rather than simply viewing knowledge as information transfer (Mehan, 1979) I advocate for explicit teaching of preservice teachers to "offset their individualistic and traditional experiences" in order to focus on student thinking (Lortie, 1975, p. 67).

One way to support pre-service teachers in their orientation toward student thinking is to teach and promote the use of student-teacher discussions in classrooms. The National Council of Teachers of Mathematics (NCTM) has advocated the use of communication-talk in classrooms for more than two decades (NCTM, 1991). Specifically, they argue that communication, through talking and writing, are central to the work of learning and doing mathematics. In fact, the mathematical thinking of many students is facilitated by hearing what their peers are thinking and in voicing their own ideas and conceptions. By putting their thoughts into words, students gain opportunities to clarify their thinking and the thinking of others. Mehan (1979) states it clearly,

> "The interactional accomplishment of social facts like answers to questions has implications for the way we view students' competence in educational environments. Instead of seeing children's knowledge as private and internal states, as a personal possession, an interactional view of teaching and learning recommends seeing knowledge as public property, social constructions, assembled jointly by teachers and students that become visible in social contexts. Teachers are sometimes not aware that the child's display of knowledge is constrained by the structure of the task, the organization of discourse, and the physical parameters of the teaching-learning situation" (p. 294).

Thus, classrooms must become settings where students engage in mathematics talk along-side their teachers.

A Shift in Mathematics Education. Focus on student understanding in mathematics began in the early 1980s. In the United States, there was widespread recognition that the quality of mathematics and science education had been deteriorating. A presidential commission reported low enrollments in advanced mathematics and science courses and the general lowering of school expectations and college entrance requirements (Ravich, 2001). In response to the realization that mathematics teaching and learning in the United States were not up to global standards, various reports and commissions to investigate K-12 education in the early 1980s developed. Two especially stand out: *An Agenda for Action* and *A Nation at Risk* (NCTM, 1980; Gardner, 1983). In spite of the NCTM's enthusiasm for the objectives of *An Agenda for Action*, the report received little attention (Middleton et al., 2004). It was largely eclipsed by the 1983 report, *A Nation At Risk. A Nation at Risk* addressed a wide variety of education issues, including specific shortcomings in mathematics education related to teacher quality and classroom instruction (Gardner, 1983). In light of changing views concerning K-12 mathematics education, policy, teacher preparation and curriculum materials experienced a shift. Teachers were expected to attend to and draw on their students' thinking as part of instruction. Classrooms became places where students were expected to engage with their teachers in rigorous mathematics, doing authentic mathematical work and participating in discussions that required higher order thinking rather than the "known information" responses of the past. Students were engaged in constructing knowledge and classrooms became labs for learning and doing mathematics actively.

In the following section I will present research on this focus on student thinking. I will review literature that focuses teachers' attention squarely on students as well as theoretical frameworks that conceptualize and support this orientation towards students and content together.

Focus on Student Thinking

Research in mathematics has produced evidence of the affordances of attending to students' thinking (Franke et al., 2007; Jacobs et al., 2007; Sfard & Kieran, 2001; Silver & Stein, 1996). But how are teachers prepared to do this kind of attending to student thinking? One example is Cognitively guided instruction (CGI). CGI is a professional development program developed by Carpenter et al., 1999. Focused on orienting teachers toward the thinking of their students, this program increases teachers' understanding of the knowledge that students bring to the mathematical learning process and the ways in which students connect that knowledge to formal concepts and operations. CGI was the first to investigate how teachers were looking at and being oriented toward student thinking. This group's work informs what we know about practicing teachers, but does not give us much purchase on pre-service teachers, early or late in their preparation. Other groups of researchers, including Franke et al. (1998), have further studied teachers' use of CGI information, finding that while teachers willingly pose initial elicitations after students complete a task, teachers find it more difficult to follow up on student explanations and to pursue students' reasoning and conceptions. Given that the teachers in this study were new to focusing on student thinking as part of their teaching practice, it stands to reason that pre-service teachers, who are also early in the work of focusing on student thinking, might display some of the same difficulties in providing responses to student explanations.

Frameworks that conceptualized an orientation towards student thinking and content together. In the following sections I describe three theoretical frameworks that I see informing how teachers enact the practice of eliciting and responding to student thinking. Given that this dissertation focuses on learning, both on the part of students and on the part of early preservice teachers, the frameworks I have chosen to highlight in this review are: (1) sociocultural and constructivist theory, (2) the instructional triangle, and (3) co-construction of knowledge. I will describe each theory in brief and detail the ways in which they relate to the practice of eliciting and responding to student thinking as investigated by this dissertation.

Sociocultural theory and constructivist theory. The work of focusing on student thinking reflects both a sociocultural perspective as well as a constructivist one. Rather than choose between a sociocultural theory that favors the views of Vygotsky or a constructivist theory that favors the views of Piaget, Van de Wall et al. (2007) advocate seven practices for teaching mathematics that blend the sociocultural with the constructivists. The practices are as follows:

1. build new knowledge from prior knowledge
2. provide opportunities to talk about mathematics
3. build in opportunities for reflective thought
4. encourage multiple approaches
5. treat errors as opportunities for learning
6. scaffold new content
7. honor diversity (p. 21-23)

In this model, the teacher's role is to create a classroom environment where a spirit of inquiry, trust and expectation is established. Within this environment, students are invited to do mathematics, and in doing so they gain confidence that their thinking and ideas matter. Rather than seeing the classroom as a place where the teacher knows everything and the student knows nothing, students re-envision themselves as knowledgeable. Positioning students as knowledgeable serves not only to engage students but also to hold them accountable. Students become accountable to their teacher and peers for sharing their thinking. Not only are students' ideas valued, but also students become obligated to share what they know in support of other people's thinking and learning. In order for novices to position students as knowledgeable they must have an orientation toward student thinking, valuing this thinking as part of the student. As

Ball (1988a) argues, students do not come to school as blank slates, but rather as thoughtful, sense-making individuals. It is then the obligation of teachers to orient themselves toward student thinking from the very beginning of their preparation.

As the obligations and roles of students change in classrooms, so do the obligations and role of the teacher. If the teacher's obligation is to simply create space for students to share their thinking, then the teacher only needs to open up the space to give students classroom airtime. If, however, the teacher is responsible for the construction or transformation of student knowledge, then the work of constructing student knowledge requires some form of evaluation and guidance toward the correct answer. Further, the work of forming and delivering knowledge-constructing elicitations requires the teacher to possess knowledge of the field (e.g. content knowledge) as well as knowledge of students (e.g. pedagogical knowledge) (Ball et al., 2008).

Instructional Triangle. The instructional triangle serves as a model to situate the work of teaching as a dynamic set of interactions among teacher, student and content (Cohen et al, 2003). Within this structure, the key players are the teacher, students, and the content, see Figure 2-2.

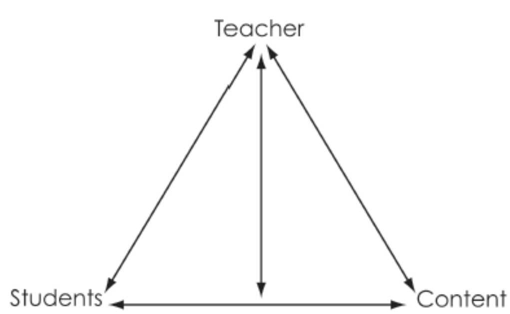

Figure 2-2: Instructional Triangle from Cohen et al. (2003).

In this model of the instructional triangle, the teacher interacts directly with students and directly with the content. The teacher simultaneously referees the student-content relationship, as depicted in the north-south arrow at the center of Figure 1-2. One interpretation for the way in which teachers can referee the student-content relationship is to use the practice of eliciting and responding to student thinking. In utilizing this practice, the teacher can elicit student thinking around particular content and learn what conceptions and misconceptions the student has related to the content. Further, the teacher can respond to these conceptions by further probing for information, posing tasks to engage students in the work around the content or even re-voicing a students' contribution. For this dissertation, we might reimage the instructional triangle positioning the early pre-service teachers at the apex, and use it to model how he or she enacts the practice of eliciting student thinking to access student thinking related to the content. Further, we might envision this work of eliciting and responding to student thinking as it occurs along the vertical line of this model, as knowledge co-construction. As teachers support interactions between students and content, they are co-creating new knowledge with their students.

Co-construction of Knowledge. A basic premise of social interaction is the construction of shared knowledge (Hardin & Higgins, 1997). Construction of knowledge is an approach to learning that draws out both the knowledge and understanding of the learner. In many cases, construction of knowledge occurs in classrooms where the teacher designs and directs tasks that support students in actively building and reorganizing their stores of knowledge. Rather than viewing learning as an individual endeavor, teachers see learning as social and collaborative, facilitating conversation and learning among students. Collaborative learning is often characterized as a process of constructing shared knowledge in which people converge on a shared meaning and representation of the materials (Roschelle, 1992). Expanding on the construction of knowledge approach, Lave & Wenger, (1991) shift the focus from the individual to the collaborative. This shift is characterized in the literature as the co-construction of knowledge. In co-construction of knowledge, learners investigate, analyze, interpret and re-organize their knowledge in relation to one another. This model for knowledge building underscores the teacher as the instigator of discussion among and with students in addition to designing and directing tasks. The task serves as the common experience on which knowledge is constructed through feedback and reflection. With feedback and reflection as the dominant vehicle for knowledge construction, communication through discussion becomes central to the work of co-constructing knowledge.

Knowing that student thinking is an essential part of co-constructing knowledge, it becomes imperative for beginning teachers to learn to support and access their students' thinking. There are good reasons to study the eliciting and responding to student thinking practice of beginning teachers. One is that eliciting and responding to student thinking is a core or high-leverage practice of teaching. It is the gateway into student minds, thinking and learning, and is the focus of all teachers' instruction. This focus makes the practice high-leverage or central to teaching. When "carried out skillfully, these practices increase the likelihood that teaching will be effective for students' learning," and are therefore crucial to developing strong training[1]. Second, knowing what beginners do at the outset of their preparation can help to focus the deliberate work of developing their capacity. Over time, teacher educators and teacher preparation programs can adjust and improve the course of study and training of beginning teachers so that the interns will become more skillful and able to elicit student thinking, to

[1] http://www.teachingworks.org/work-of-teaching/high-leverage-practices; TeachingWorks, the University of Michigan, Ann Arbor.

support student learning, and to increase student achievement.

Models for co-constructing knowledge in elementary mathematics classrooms. In an effort to increase the amount of high quality talk in classrooms, Chapin et al. (2009) prescribe a three-part cycle for productive talk. In this cycle the three productive talk practices a teacher must employ are: (1) planning and projecting: creating a road map, (2) improvising and responding: in the midst of the lesson, and (3) summarizing and solidifying: so where are we now? (p. 44). In the first practice, the teacher is able to work independently before students arrive for the lesson. The work of planning allows a teacher to identify the mathematical ideas, often given in the curriculum, as well as the mathematical concepts and procedures that are likely to arise during instruction. Planning and projecting give the teacher time and space to think about which math tasks, problems and talk formats might be used during instruction and which student misconceptions may arise and need to be addressed.

The second practice, improvising and responding, takes place live and during the instruction. It requires the teacher to respond in the moment to student ideas and representations. Since no teacher can fully plan and project in part one what will occur in part two, all teachers experience some sense of uncertainty when engaging students in classroom discussion. For the third and final practice, summarizing and solidifying, the teacher utilizes the information revealed in part two to formulate a verbal and/or written account or summary. It is an opportunity for the teacher to have the last word, to leave students with a review of the lesson, or to clarify or solidify a particular concept or idea for the whole group. This summary is not completely improvised, as the teacher can plan for it given the learning goals, curriculum materials and the planning and projecting done in part one.

Chapin et al. (2009) further develop this model by prescribing what they refer to as "talk moves" for part two, improvising and responding: in the midst of the lesson. "Talk moves" are suggested verbal actions on the part of the teacher, which have been found to be effective for making good progress toward achieving instructional goals of a lesson and in supporting students' mathematical thinking and learning (p 12). Figure 2-3 below lists the five talk moves with accompanying examples.

Move 1: Revoicing. ("So you're saying that it's an odd number?")
Move 2: Repeating: Asking Students to Restate Someone Else's Reasoning. ("Can you repeat what he just said in your own words?")
Move 3: Reasoning: Asking Students to Apply Their Own Reasoning to Someone Else's Reasoning. ("Do you agree of disagree and why?")
Move 4: Adding on: Prompting Students for Further Participation. ("Would someone like to add something more to this?")
Move 5: Waiting: Using Wait Time. ("Take your time . . . we'll wait . . . ")

Figure 2-3: Five Talk Moves from Chapin et al. (2009).

These talk moves replace the "E" for evaluate from Mehan's (1979) IRE structure. Instead of evaluating students' responses as right or wrong, the teacher supports students in sharing their thinking with the class.

Another model of classroom interaction that focuses on the work of engaging in Chapin et al.'s second practice of productive talk, improvising and responding, can be found in Lampert's writing about her own elementary teaching. Lampert (2001) models what she calls a "particular kind of interaction that would be used to teach students to engage in mathematical sense-making" (p. 61). The three elements of this model are:

1. soliciting more than one contribution
2. responding to each contribution in a way that communicated my [the teacher's] understanding (not necessarily approval) of what the student was saying
3. asking students to re-voice the contributions of other students

We might think about the first element as similar to the eliciting portion of the practice of eliciting and responding to student thinking. The second two elements could be taken together and thought of as the responding to student thinking that teachers engage in. A teacher could, respond as described in the second element, or the teacher could respond using the third element, asking students to re-voice the contributions of other students. This third element, in particular, is one move I have seen pre-service teachers use in their practice of eliciting and responding to student thinking and gives me reason to believe I may see some requests to re-voice as part of the practice of the pre-service teachers in this dissertation study.

Eliciting

In this section I review literature related to the practice of eliciting student thinking. Although this dissertation focuses on the combined work of eliciting and responding to student thinking, there are researchers who distinguish the two and are focused on eliciting as a singular practice. Others combine eliciting and responding to student thinking with the work of interpreting student thinking. For this section of the review, I included research that both named eliciting and described the work of eliciting. In many cases the work of eliciting is called questioning or refers to the work of posing questions to engage student thinking, learning and actions. I chose to include a breadth, as well as depth, of research I felt related specifically to the practice of eliciting and responding to student thinking as I have defined in the introduction chapter of this dissertation.

Using questions to learn about student thinking. Clasen and Bonk (1990) argue that the level of student thinking is directly proportional to the level of the question asked. So it seems logical that teacher questions are both related to and useful in determining student thinking. If we agree that the quality of student thinking is influenced by the quality of the questions the teachers poses, then it makes sense to be interested in the kinds of questions teachers are using to access student thinking and the purposes they intend to accomplish with these questions. According to Morgan and Saxton (1991) teachers pose questions for several reasons: (1) as a way to keep students actively involved in lessons, (2) to provide students the opportunity to openly express their ideas and thoughts, (3) to enable other students to hear different explanations of the material by their peers, (4) to support the pacing of a lesson and moderate student behavior, and (5) to evaluate student learning and revise instruction as necessary. Given the importance both Clasen and Bonk (1990) and Morgan and Saxton (1991) place on the work of asking questions, it follows that the practice of asking questions to promote student thinking is important to study. If teacher education is to be positioned to support the practice of asking questions through eliciting and responding to student thinking, then understanding the purposes novices bring to question use is essential in supporting their growth and development of skillful practice in this area.

Mid-century research studies of teacher-questioning practice describe educators as "generally agree[ing] that teachers should emphasize the development of students' skills in critical thinking rather than in learning and recalling facts" (Aschner, 1961; Carrier, 1963; Hunkins, 1966 in Gall 1970, p. 712). Hunkins' (1969) research sought to determine if varying question types during instruction would impact student achievement, specifically in sixth grade social studies. Importantly, Hunkins defined question types in terms of Bloom's Taxonomy, finding that students in the "analysis-evaluation group earned… significantly higher" scores on the common post test than students who answered questions that "stressed knowledge" (Gall, 1970, p. 714). This comparison of students engaged in analysis-evaluation vs. knowledge memorization describes a current pattern. Specifically, questions posed to students that require analysis result in greater student achievement, when compared to more limiting questions that focus on knowledge memorization and recall (Brualdi, 1998).

Narrow questions with single prescribed answers, referred to as "shrinking" questions by Schiever (1991), limit student thinking by focusing on factual recall rather than underlying constructs and reasoning. Sadly, Wilen (1991) documents that teachers spend most of their time asking these kinds of low-level cognitive questions. These types of questions concentrate on factual information that can be memorized (e.g., What is the formula for the area of a triangle?), rather than questions that require and draw out students' conceptual understanding (e.g., What is the relationship between the formulas for the area of a rectangle and the area of a triangle?) Low-level questions that have a prescribed, memorized answer, fail to engage the learner. They require little investment in students' thinking and negate the required analysis and evaluation that support learning and memory making (Franke et al., 2009).

In contrast, Sanders (1966) views good questions as a way to, "recognize the wide possibilities of thought and are built around varying forms of thinking. Good questions are directed toward learning and evaluative thinking rather than determining what has been learned in a narrow sense" (p. ix). Good questions provoke thought and necessitate analysis and evaluation on the part of the learner. Further, Gall (1970) states that, "effective question types [are] defined in terms of whether or not they enabled the student to achieve desired educational objectives" (p. 711). In other words, the lesson's learning goals should dictate questions that require students to engage with multiple perspectives.

Using questions to elicit student thinking in mathematics. Lobato et al. (2005) explain that, "eliciting" student thinking occurs when the teacher's actions serve as a way to draw out students' "images, ideas, strategies, conjectures, conceptions, and ways of viewing mathematical situations" (p. 111). The teacher may elicit by posing a carefully designed task or by asking one student to respond to the ideas of another student. Specifically, the "eliciting actions occur when the teacher arranges for situations in which students articulate, share, discuss, justify, reflect upon, and refine their understanding of the mathematics" (Lobato et al., p. 112). Rather than provide answers to be recalled later, the teacher creates a classroom environment that allows students to be curious and to explore their thinking, and the thinking of their classmates (Schifter & Simon, 1992). The teacher does not impose his/her own ideas or understanding on the students by telling them what to think. Instead he or she asks questions in order to understand what the students are thinking.

To begin to understand students' thinking, the teacher may start by presenting mathematical problems, tasks, or situations. Then, the teacher surfaces the important mathematics of the task as well as the thinking of the students about this mathematics, "by eliciting an explanation and engaging the students intellectually instead of providing explanations to students" (Lampert et al., 2013, p. 238). This method is in sharp contrast to some teaching methods, which "tell" students what to think and then require them to repeat the process until it becomes rote. Such methods lack a focus on sense-making; they do not acknowledge children as sense-makers or people who make contributions to the discussion based on ideas and thinking from past and current experiences. Rather than ignoring students' prior knowledge, or trying to erase it all together, the practice of eliciting and responding to student thinking seeks to define and understand what children are thinking and why (Smart & Marshall, 2012).

Once this thinking is uncovered, it can then be used as a foundation for ideas and connections to prior and new mathematics learning. Students' confusions and misconceptions can be addressed and repaired, while new knowledge is then constructed on this repaired foundation. However, this process requires a teacher who is skillful at gaining access to individual student's thinking. If a teacher is uninformed or unaware of a student's thinking, s/he is not in a position to repair or build upon this thinking. Furthermore, s/he will likely create greater confusion or risk building on an unsteady foundation that could someday result in a problematic breakdown of knowledge and understanding.

The practice of asking questions to elicit student thinking. Smart and Marshall (2012) highlight the concept that "utilizing higher-order questioning and more student-centered discourse" requires teachers to be more flexible in their own instructional practices (p. 266). Teachers with "higher levels of content knowledge" may be more comfortable with the "open-ended nature of tasks that require students to engage with divergent modes of thinking" (p. 266). If teachers are not proficient in their own content knowledge, they may be more likely to rely on lower-order questions with a specific, pre-determined answer. The practice of asking questions is not solely about posing questions. It also requires a depth of content knowledge. In fact, teachers whose question asking practice centers on lower level cognitive questions may in fact be lacking in content knowledge, rather than skill in posing questions. For this reason, questioning practice must be joined with content knowledge in order to create learning settings that promote student inquiry and thinking.

Lampert et al. (2013) also describe the many related skills a teacher must learn in order to be proficient at questioning. Eliciting and responding to student thinking is a teaching practice that embodies the "nuances of interactional-related elements" (p. 240). It requires a teacher to possess knowledge of students, knowledge of eliciting practice, and knowledge of mathematics content, and knowledge of how to respond to students in ways that promote thinking and understanding. A teacher must be able to juggle all of this knowledge successfully in eliciting and responding to elementary students. This task can seem daunting, as a teacher must be attuned to not only one elementary student, or one contribution, but to a series of contributions that are both unpredictable, and potentially confusing, not only for the teacher but for the classroom of students as well. How is this practice of asking questions to elicit student thinking learned?

Learning to elicit and respond to student thinking. In a research review on questioning practice, Wilen and Clegg (1986) suggest that teachers employ the following research-supported *practices* to foster higher student achievement (emphasis added). Here, practices, plural, refer to the multiple techniques that are used within the teaching practice, singular, of posing questions. Within the practice of posing questions the teacher: (1) phrases questions clearly, (2) asks questions of primarily an academic nature, (3) allows three to five seconds of wait time after asking a question before requesting a student's response, particularly when high-level cognitive questions are asked, (4) encourages students to respond in some way to each question asked, (5) balances responses from volunteering and non-volunteering students, (6) elicits a high percentage of correct responses from students and assists with incorrect responses, (7) probes students' responses to have the students clarify ideas, support a point of view, or extend their thinking, and finally, (8) acknowledges correct responses from students and uses praise specifically and discriminately (p. 23). Wilen and Clegg's (1986) list of practices describe what the teacher is doing during instruction. The seventh of the techniques described is most similar to the practice of eliciting and responding to student thinking, which is the basis of this research. Here, they describe the teacher's work of using questions to "probe" student responses as doing one of three things: (1) clarifying ideas, (2) supporting a point of view, or (3) extending thinking. The teacher is not questioning the students to elicit a memorized fact or prescribed response, but rather is asking questions to gain insight into students' ideas. These questions are eliciting the students' point of view or background knowledge and asking for information about how students are able to connect and extend their current thinking to other domains.

What makes eliciting and responding to student thinking so difficult? One reason that learning to elicit student thinking is so difficult is, "the knowledge, skill, and principles necessary to elicit student performance and respond to it productively are not static; they develop as they are used in the form of 'adaptive expertise'" (Bransford et al., 2005 in Lampert et al., 2013, p. 228). Adaptive expertise is, "a kind of competency that involves being fluent with routines in order to work efficiently and innovate when necessary, rethinking key ideas, practices, and values in order to respond to non-routine inputs" (Lampert, 2009, p. 24). In this paper, Lampert uses, "the work of calling on students" as an example of adaptive expertise. After reading this definition eliciting and responding to student thinking immediately came to mind. Skillful enactment of the practice of eliciting and responding to student thinking requires teachers to "rethink key ideas… in order to respond to non-routine inputs." Ideas are re-thought in order to attend to and follow student thinking. This practice also means that the response must then be specific to a student's contribution, making all responses non-routine since they are in direct relation to student thinking and all the variations of this thinking.

In the context of teacher education, specifically, preparing pre-service elementary teachers for mathematics instruction, Lampert et al. (2013) define the teaching practice of eliciting and responding as, "eliciting, interpreting, and responding to student mathematical work or talk" (p. 231). In this definition, elementary-aged students present mathematics work, often written or pictorial representations, or oral contributions about the mathematical task they are engaged in with the teaching intern. Not only must the intern elicit these contributions, but s/he must interpret the information offered, whether verbal or written, in light of the mathematical content and learning goals of the lesson. Then s/he must respond to the student by doing three things: (1) positioning the student as a sense-maker who is competent and thoughtful about the mathematics, (2) making the student's contribution and thinking available to other students in the discussion, and (3) meeting the instructional goals of the lesson. This is a tall order for even experienced teachers. If we take into account the practice of pre-service teachers, many of whom have not made the switch from thinking like a student to acting like a teacher, then we can expect the work of this practice (see numbers 1-3 above) to be challenging. It is even more likely that the practice of eliciting and responding to student thinking will be challenging for preservice teachers early on in their program. But how challenging is the work of enacting this practice for preservice teachers early on in their preparation? And how might teacher education take steps in investigating and describing what early eliciting and responding to student thinking practice looks like?

In their 2013 paper, Lampert et al. describe the way in which teacher educators support novice teacher learning, using rehearsals. Rehearsals are a kind of approximation of practice that are designed, "based on the assumption that mathematics teachers need to learn to elicit, observe, and interpret student reasoning…in order to promote [student] learning," of mathematics (p.

227). Rehearsals serve as "containers" for core teaching practices to be practiced, (McDonald et al., 2013, p. 382; Lampert et al., 2013, p. 228). Rehearsals for teaching practice, as Lampert et al. (2013) describe them, are carefully planned settings, which teacher educators use to support pre-service elementary teachers in their teaching practice. Their paper describes multiple practices that are "rehearsed" or practiced during teaching rehearsals, including "eliciting and responding to" elementary student contributions (p. 228). This work is of particular relevance to this dissertation given that the preservice teacher participants engage in rehearsals as part of their first four weeks of teacher preparation. Understanding the purposes and use of rehearsals sheds light on some of the experiences and learning of the participants from this dissertation study.

In rehearsals, teaching complexities are controlled by the facilitating teacher educators, who in conjunction with district administrators and faculty, design the school enactments, "to enable the participation of all [elementary] students and for the novice [teachers] to elicit and build on students' mathematical thinking while working on a range of mathematical ideas in number and operations" (p. 288). While this paper details the judicious and strategic ways in which teacher educators construct and carry out instruction, there is no description of the teaching that interns engage in with actual elementary students after rehearsals. Lampert et al.'s (2013) focus is on describing the opportunities beginning teachers have as they learn to enact the principles, practices, and knowledge of eliciting and responding to student thinking, not their individual practice in a school-based practicum setting, which is what this dissertation will do.

"E" for evaluation becomes "E" for extension and elicitation

Focusing on the thinking and understanding of students is in contrast to Mehan's (1979) IRE model. With student ideas at the forefront of classrooms, teachers are no long responsible for simply evaluating student responses, but also for extending and further eliciting these responses in order to develop and deepen students' mathematical conceptions. Therefore, I propose an amendment to the IRE frame of classroom talk. Instead of initiate-response-evaluate, I advocate for a pattern of initiate-response-extend and elicit to describe teacher and student discourse in classrooms.

This new pattern of initiate-response-extend and elicit can be seen in examples of experienced teachers' eliciting and responding to student thinking practice. Chapin et al. (2009) provide an example of an experienced teacher, Mrs. S, eliciting and responding to student thinking:

1. Mrs. S: I'd like each of you to explain your thinking to me. I'd like each of you to explain to me why all of the shapes in this group are triangles [points to the equilateral triangles] and all of these are not triangles [points to some triangles in the "other" group].

2. Ollie: This [points to one equilateral triangle] just looks like a triangle.

3. Mrs. S: In what way? (p. 27)

In this example, Mrs. S elicits Ollie's thinking by asking, "In what way?" She is asking Ollie to explain his thinking about what makes this particular triangle an equilateral triangle. In doing so, she develops his thinking and talk about the definition of an equilateral triangle and how it differs from the definition of any or all triangles.

In a second example of an experienced teacher's discussion practice, we see Lampert (2001) using the fourth Chapin et al. (2009) talk move, "adding on" to extend her fifth grade student's thinking.

Lampert: Okay, that's one good way of explaining revision. Let's see, Shahroukh was another person who had an idea.

Shahroukh: I think she's got my idea.

Lampert: Is there anything you would like to add to what Charlotte said? (Lampert, 2001 p. 62)

Rather than accept Shahroukh's response of "I think she's got my idea." Lampert invites the student to "add" to what has been said. This question does not allow the student to remain passive, but invites and requires Shahroukh to share her thinking. In doing so, Lampert reinforces the student's role as an important and contributing member of the classroom talk who is responsible for sharing her thinking with the group.

For another example of an experienced teacher's eliciting and responding to student thinking practice, we turn back to Mrs. S. She continues to engage her third grade students around the definition of triangles. She employs the Chapin et al (2009) talk move, repeating; asking students to restate someone else's reasoning in this example:

1. Mrs. S: What does a triangle look like?

2. Paul: Hmmm. [Paul looks around the room and then points to a poster of geometric shapes. The shapes on the poster are all regular polygons and the triangle on it is equilateral.] Like that one. See, triangles just look like this [cups hands into the shape of an equilateral triangle]. They're flat on the bottom.

3. Mrs. S: Ollie, what did Paul just say? (Chapin et al, 2009, p. 28)

Rather than evaluating the correctness of what Paul has just stated, Mrs. S elicits Ollie's thinking, asking him to repeat or restate what Paul has just explained about triangles. In doing so, Mrs. S opens up Paul's thinking for Ollie and the rest of the students to learn from.

As both Chapin et al. (2009) and Lampert (2001) display, a teacher's focus on one student's thinking can support and develop the thinking of an entire classroom of students. Instead of evaluating students' responses as in the traditional IRE discussion model (Mehan, 1979) these teachers are utilizing their third turn of talk to ask questions that elicit and extend student thinking. In this way, teacher questions become the catalyst for student thinking. They serve to develop student conceptions about mathematics and guide the ways in which the classroom, as a community of learners, talk about and engage in the work of doing mathematics.

Summary

In everyday life we do not ask the same kinds of questions as we do in classrooms. It is unlikely that we will evaluate our friend's response to a question, saying "Correct. Good job!" Nor is probing for more information a regular feature of everyday interaction and conversation. Instead, it is specific to classrooms conversations and interactions. However, we do see aspects of everyday conversation creeping into teaching practice, especially when looking at preservice teachers' practice. This tendency is due to the fact that most novices have not yet become versed in the kinds of language and conversation that is special to teaching and learning. It is likely that early on in their professional training preservice teachers will be in the process of making this shift from everyday to professional discourse. Therefore, as a researcher analyzing this dissertation's data, I might expect to see some examples of language and conversation that don't make the shift to school discourse.

Research Questions

In order to further investigate and describe the preservice teachers early practice of eliciting and responding to student thinking, this dissertation poses the following research question:

What does the practice of eliciting and responding to student thinking look like as it is being learned by preservice teachers during elementary mathematics instruction?

Specifically, I want to uncover and describe patterns of novices' practice of eliciting and responding to student thinking in elementary mathematics instruction. I plan to do this by noticing and analyzing, for the preservice teachers in my sample:

(1) the kinds of initial eliciting questions novices seem to pose, and

(2) the kinds of responses to student answers novices seem to give.

Chapter 3

METHODS

Introduction

This dissertation investigates preservice elementary teachers' enactment of the practice of eliciting and responding to student thinking early in their preparation program. By "early" I refer to the work preservice teachers do with elementary students within the first weeks of their teacher preparation program. The study aims to explicitly describe aspects of eliciting and responding to student thinking that early preservice teachers do well and do less well. To do this, I analyzed video records of 27 preservice elementary teachers, called interns, leading small group mathematics discussions during the third week of their year-long preparation program. This chapter describes these data and the methods of analysis used.

I begin by explaining my role as a researcher and participant in this dissertation study. I also detail my rationale for the study's design, in particular, why I focused on week three of preservice elementary teachers' preparation. I then turn to the methods of data analysis, organized according to my research questions.

Rationale for Study Design

For their summer teaching and learning, instructors provided interns with lesson plans for each week's teaching. During the first two weeks of teaching and learning, interns were given highly scripted lesson plans which included lists of questions and explanations to use when eliciting and responding to student thinking. For the third week of teaching, interns were given a shorter, less scripted lesson plan. This third week was the first opportunity interns had to apply the kinds of eliciting questions they had practiced from the scripted plans in weeks one and two. I was interested in how interns would adjust their teaching and work from a less scripted plan. For this reason, I chose to closely examine interns' third week of practicum teaching. I will provide more details about the content of these lesson plans later in this section.

My Role as a Researcher and Teacher Educator

I have been involved in the one-year master's degree teacher education program for several years. I first apprenticed in the Mathematics Methods Course in the fall of 2011. This course was designed around a University-School partnership, which meant that our University course met at a local, public elementary school in an unused classroom. The course also featured an after school, field-based practicum where interns lead mathematics discussions and activities. Through observations of interns in the methods course and in the field, I first became interested in preservice teachers' ability to engage with student thinking in mathematics. Since this time, I have been involved in planning, observing, and giving feedback to preservice teachers for this course. In the fall of 2014, I had an opportunity to serve as the primary instructor for the course, where I noticed variation in interns' practice of eliciting and responding to student thinking. Assessing and providing feedback on the interns' practice also highlighted the variation in their conception and enactment of eliciting and responding to student mathematical thinking.

In the fall of 2012, I also became involved in year-long field placement for the interns in the master's program as a field instructor. During that year, I supervised five interns in their elementary classroom field placements. My involvement in interns' teaching both in university course settings and in elementary classrooms has also allowed me to notice the wide variety of interns' orientations toward student thinking, as well as eliciting and responding to student thinking practice during mathematics discussion. Having the opportunity to work with classes across multiple time points in the program made me wonder about how interns might first learn to do the work of eliciting and responding to student thinking.   I also became interested in how interns were making sense of their student contributions and the kinds of responses they employed given the correctness of a student's answer.

During this dissertation study I served as one of three instructors for the program's summer course with field-based practicum, and as the primary researcher for this study. My assuming these roles required that I define each ahead of time (Luft, Bragg, & Peters, 1999). For this summer course, a local, public elementary school served as the site for both University coursework and teaching practicum. As an instructor, I co-planned, observed, and provided feedback on the mathematics teaching interns taught in their practicum classrooms. As an instructor of the Mathematics Content and Methods Course, I co-planned, observed, and provided verbal and written feedback on interns' mathematics teaching in their practicum classrooms. As a researcher, I obtained consent from interns to be involved in the study and informed interns that their involvement would not be related to the grades for the course. Since I did not conduct interviews with interns, nor requisition materials apart from those required by the course and its syllabus, all of the data collected for this dissertation study were artifacts generated for the purposes of the course and not my research. Finally, my instructional involvement with these interns was completed before I began the analysis of their teaching for the purposes of this dissertation.

Participants

The participants of this study were 27 graduate students (21 women and 6 men). All participants held a bachelor's degree in a field other than education, and were enrolled in a one-year master's degree program with K-8 teaching certificate. Of the 27 participants, five self-identified as underrepresented minorities in teacher education settings. Table 3-1 gives a more comprehensive picture of these interns. To anonymize these participants, all intern names are pseudonyms and reflect culturally similar names or names similar in popularity to their real names. To distinguish the graduate student participants from the elementary aged students they teach, the graduate student preservice teachers will hereafter be referred to as "teaching interns," and the elementary children (who are rising third graders) will be referred to as "students."

Table 3-1: Intern Descriptives

Name	Gender	Race/Ethnicity	Age (in years)*	Career Change	Directly out of Undergrad
Allison	Female	White	22		✓
Beth	Female	Latino	25		
Brooke	Female	White	24		
Chad	Male	White	26	✓	
Colin	Male	White	27		
David	Male	Latino	24		
Debbie	Female	White	25		
Haley	Female	White	23		✓
Hannah	Female	White	23		✓
Henry	Male	White	27	✓	
Kathleen	Female	White	24		
Keith	Male	White	24		
Kendra	Female	White	24		
Kit	Female	Asian	23		✓
Maggie	Female	White	23		✓
Melanie	Female	Non White, Non Latino	22		✓
Mindy	Female	White	24		✓
Polly	Female	White	25		
Pricilla	Female	White	31		
Sandra	Female	White	27	✓	
Stacy	Female	White	25		
Tara	Female	White	25		
Todd	Male	Black	49	✓	
Valerie	Female	White	29	✓	
Veronica	Female	White	24		
Wendy	Female	White	24		
Zoe	Female	White	28		

* Age is reported at time data were collected (July 2012)

Context of the Study

The context for my research is a graduate level teaching certification program in a School of Education located within a large midwestern university. Individuals enrolled in the one-year (June-May) Elementary Ed Program. A hallmark of this program is the time interns spend working with actual elementary-aged students in teaching settings called "teaching internships" or practicum. A description of the interns' coursework and internships by semester can be found in Table 3-2.

Table 3-2: Overview of Elementary Ed Program

Semester	Dates	Coursework	Teaching Internship
Summer	June-July 2012	Literacy Content & Methods 1 Mathematics Content & Methods 1	Yes
Fall	August-December 2012	Literacy Content & Methods 2 Mathematics Content & Methods 2 Social Studies Methods Educational Linguistics Education Technology Exceptionalities/Special Ed	Yes
Winter Part 1	January 2013	Science Methods	No
Winter Part 2	February-April 2013	Teaching & Learning Methods	Yes
Spring	May 2013	Research & Education Practice	No
OPTIONAL[2]	June-July 2013	ELL Endorsement	Yes

[2] Graduate Students were given an opportunity to take an additional semester of coursework and teaching internship to obtain their English Language Learner (ELL) teaching certificate endorsement.

School-based summer teaching. All records of teaching practice are from a school-based site during the summer of 2012, where graduate students engaged with elementary-aged students in classrooms during the morning for practicum, and attended university courses (held at the school-based site) in the afternoons. The school-based site is a local elementary school building designated to house the district's month long elementary Summer School Program, (or SSP). The SSP was developed to combat the summer "backslide" many students experience during the months of July and August when they are not attending school.

The SSP's suburban district is 70% white, non-Latino, with 23.5% of the students receiving free-reduced lunch. In 2014 third graders district-wide scored in the 80th percentile for ELA and in the 67th percentile for mathematics on state standardized tests.[3] The SSP focused on a subset of the population who were labeled "at risk" based on below proficiency test scores, and included a higher percentage of both underrepresented minorities and students receiving free-reduced lunch. During the summer of 2012, the district invited a little over 300 elementary school students to participate in the SSP based on two criteria: (1) recent completion of either kindergarten or second grade, and (2) a below proficiency score on the district English Language Arts (ELA) benchmark tests given at the end of the school year. While ELA test scores inform the selection of students for participation in the SSP, the SSP has both an ELA and a mathematics component for all students.

Mathematics teaching opportunities during the summer semester. During the summer semester interns took two university courses, one focused on teaching practice and subject matter

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[3] http://splash.[state]-school.net/gvsucso/compare.aspx

knowledge for teaching literacy, and the other for teaching mathematics. The interns spent half of the morning engaged in mathematics instruction and practicum and half of the morning engaged in English Language Arts instruction and practicum. During mathematics methods instruction, interns engaged with university course instructors, learning the mathematics curriculum and rehearsing the eliciting and responding to student thinking practice they would use during their practicum with students. All students had just completed their second grade school year and were considered “third graders” during the SSP. For rehearsals during the methods course, interns and instructors divided into two groups with interns rotating role-playing the teacher and third grade students. During the practicum, interns observed a whole class mini lesson led by the mentor teacher. After the mini lesson, the mentor teacher worked with half of the students (approximately 6) while two interns lead separate mathematics activities with 2, 3 or 4 students (depending on attendance). These activities lasted for on average 12 minutes.[4] Table 3-3 shows this schedule in greater detail.

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[4] Table 3-3 indicates that interns and elementary students had 15 minutes for their mathematics activities, but these teaching activities lasted closer to 12 minutes because time was spent gathering and cleaning up materials and transitioning students from one activity to the next.

Table 3-3: Intern Summer Semester Mathematics Methods Instruction and Practicum

Setting	Time	Activity	Participants
Methods Classroom	8:30-9:00 AM	Overview and Content	<u>Whole Group</u> 3 Instructors 14 Interns
	9:00-9:50 AM	Rehearsals	<u>Two Groups</u> Group A: 2 Instructors and 7 interns Group B: 1 Instructor and 7 interns
Practicum Classroom	9:50-10:10 AM	Mentor teacher leads mini lesson	<u>Whole Group</u> 1 Mentor teacher 3 Interns observing 12 Students
	10:10-10:25 AM	Intern led mathematics activity with discussion	<u>Three Groups</u> Group A: Mentor teacher with 6 students Group B: 1 Intern with 3 students Group C: 1 Intern with 3 students 1 Intern observing
	10:25-10:40 AM	Intern led mathematics activity with discussion	<u>Three Groups</u> Group A: Mentor teacher with 6 students Group B: 1 Intern with 3 students Group C: 1 Intern with 3 students 1 Intern observing

During the morning mathematics methods course, intern learning was focused on four objectives: (1) learning the mathematics activities, called curriculum, that they would lead in a small group with third graders, (2) learning the mathematics content of the activities, (3) learning about student understanding, both conceptions and misconceptions, and (4) learning how to elicit students' thinking during the mathematics activity to support thinking and learning. The last of these objectives is specifically relevant to my focus on interns' practice of eliciting and responding to student thinking. For the summer semester, our focus on eliciting student thinking began during week 1 and became a focus of both practicum and University-based course work during week 3. This focus for week 3 is another reason why I chose it as the week for my dissertation research.

The model of teacher preparation, where interns spend time learning content and rehearsing instruction, is based in Magdalene Lampert's research and instruction in teacher preparation programs (Lampert et al., 2010; Lampert & Graziani, 2009). Lampert et al. (2013) describe rehearsals where interns, "engaged collaboratively" with instructors and intern peers and "tried on" teaching practice before engaging with elementary students (p. 239). Following Lampert et al.'s program, this group of interns developed three mathematics teaching practices: (1) eliciting students' mathematical ideas, (2) orienting students, and their ideas to one another, and (3) following a particular student's mathematical thinking. These practices were first rehearsed in the methods classroom, then they traveled with interns to their practicum classrooms, (Lampert et al., 2013, p. 228) and finally were enacted with elementary students. As you will notice in later chapters of this dissertation, the codes I created and employed for my analysis reflect all three of these teaching practices. The teaching and learning setting for the interns in this study was strategically designed so that interns' opportunities to engage in methods course instruction was located in the same school building as the practicum classrooms where they enacted instruction.

Practicing eliciting and responding to student thinking during pre-teaching rehearsals. During pre-teaching rehearsals interns focused on eliciting student thinking around the weekly mathematical activity and getting students to talk about the mathematics using elicitations and other responses to student contributions. The set up of these rehearsals included one intern acting as "teacher" with 2-3 intern colleagues acting as "students" along with the teacher educator, also acting as a "student." Each "teacher" used the lesson plan he or she had written to rehearse the teaching episode (which included discussion and game play). The teacher educator coached interns to begin the discussion with an initial elicitation using a question that was open, neutral and focused on student thinking (e.g., What did you do first?) Interns practiced responding to their colleagues acting as "students" by asking follow-up questions that probed the "student's" thinking and understanding about the addition of 10 or 1 (e.g., What is happening with the digit in the ones place?).[5] Additionally, interns practiced teaching behaviors involving tone and manner, including (1) positioning the game board so that all students can see and participate, (2) facing the student or using a first name when asking a question, and (3) using language that is accessible, mathematically accurate and appropriate for students.

Description of the curriculum for the Summer School Program. In alignment with district, state and national standards, the SSP curriculum for mathematics instruction focused on base ten number and operations.[6] Within this strand, the curriculum focused on addition and subtraction within and to one hundred. Specifically, the Grade 2 Common Core State Standards in Mathematics (CCSSM) that were addressed by the SSP curriculum are found in Figure 3-1:

[5] Boerst & Shaughnessy, 2012, Baseline Assessment
[6] CCSS.MATH.CONTENT.2.NBT.B.5 and B.9, http://www.corestandards.org/Math/Content/2/NBT/

Use place value understanding and properties of operations to add and subtract.

CCSS.MATH.CONTENT.2.NBT.B.5 (HTTP://WWW.CORESTANDARDS.ORG/MATH/CONTENT/2/NBT/B/5/)

Fluently add and subtract within 100 using strategies based on place value, properties of operations, and/or the relationship between addition and subtraction.

CCSS.MATH.CONTENT.2.NBT.B.9 (HTTP://WWW.CORESTANDARDS.ORG/MATH/CONTENT/2/NBT/B/9/)

Explain why addition and subtraction strategies work, using place value and the properties of operations. [1]

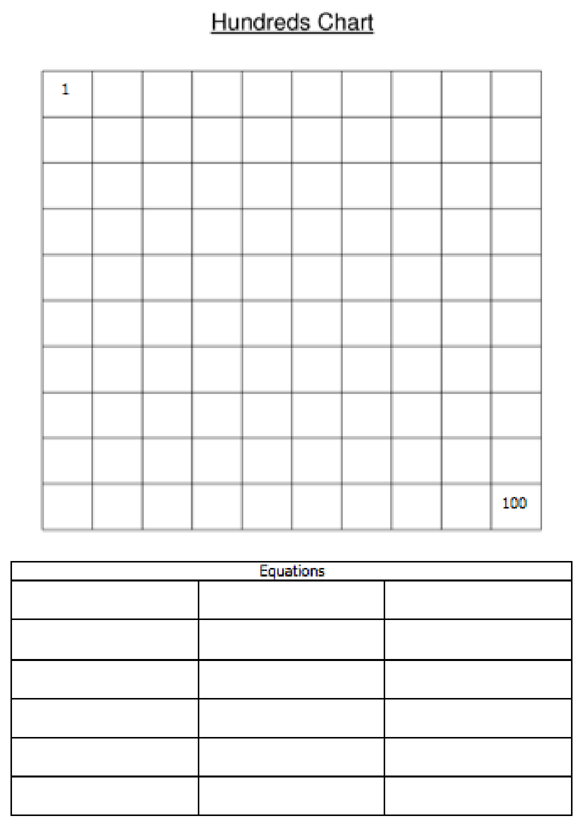
[1] Explanations may be supported by drawings or objects.

Figure 3-1: Grade 2 Common Core State Standards in Mathematics – Number & Operations in Base Ten.

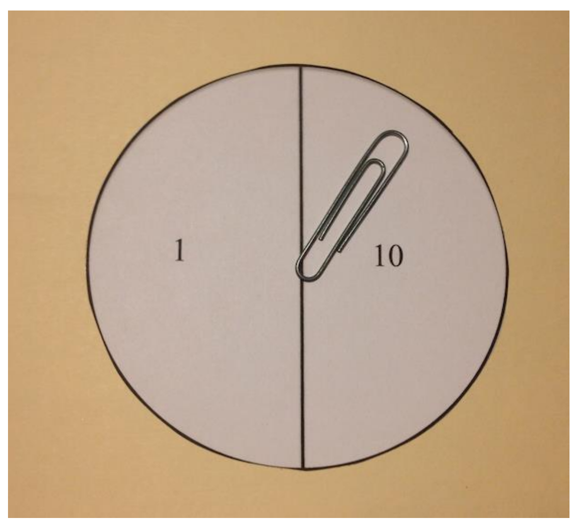
Interns focused their instruction on "strategies based on place value" and supporting elementary students to "explain why" these strategies worked in the context of a place value representation called the hundreds chart. The hundreds chart served as the game board for the interactive addition game called *Pathways to 100* (Burns, 2008).

The game: "Pathways to 100." Over the course of this week of practicum, interns engaged students in a specifically rich mathematics task, a game called "Pathways to 100." This game served as the context for the mathematical work in which students engaged, and that interns used to practice eliciting and responding to student thinking.

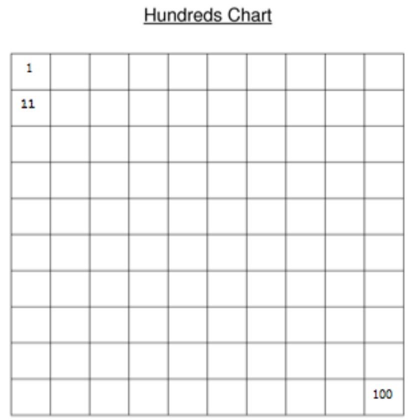
The game board consists of two parts: First, an open hundreds chart which is a 10 x10 grid that has only the number 1 and 100 filled in, with all the other spaces "open" or blank, hence the term "open hundreds chart" (see figure to the right). Second, a space for recording addition equations that emerge from game play described below.

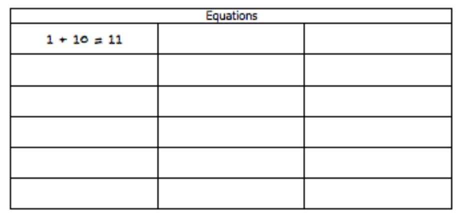


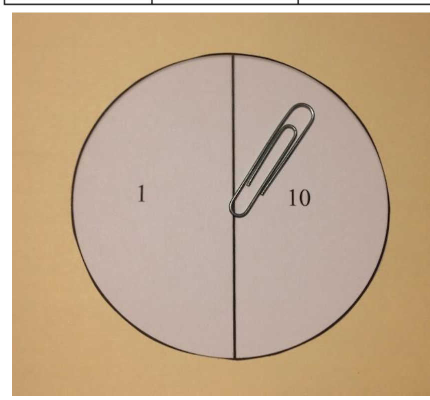
In addition to the game board the game also utilizes a spinner. The spinner is a circle that is divided into two equal halves like a pie chart. One half is marked with the number 1 and the other half with the number 10 (see figure to the right). The spinner is used to add either 1 or ten to an existing number on the hundreds chart.



For example, when game play begins, the existing number on the chart is 1. You can see this written in the uppermost left square of the Hundreds Chart (at the right). If a 10 is spun, this 10 from the spinner is added to the 1 (existing number on the chart) to make 11. Thus, the resulting equation is 1 + 10 = 11. For this equation the first addend, 1, is the existing number on the chart. The second addend, 10, is the number spun using the spinner. The sum, 11, is found when the addends from game play are added together. In this way the equation represents each round or spin of game play. As the game continues students spin a sequence of 1s and 10s. The spins are recorded on the hundreds chart and in the equation section of the game board.





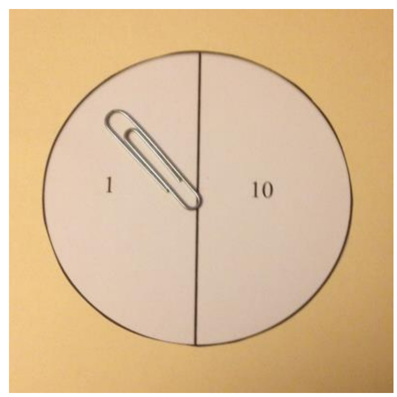


If the students spin the same number repeatedly for two or more turns, a pattern begins to emerge on the hundreds chart. For example, if a 1 is spun for three sequential turns, the numbers form a row going across the chart from left to right.

Hundreds Chart

1									
11	12	13	14						
									100

Equations		
1 + 10 = 11		
11 + 1 = 12		
12 + 1 = 13		
13 + 1 = 14		

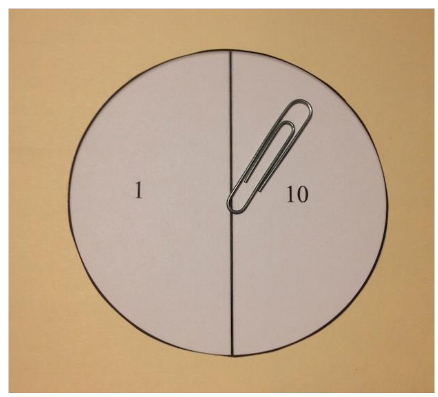


When a 10 is spun this changes the direction of the pathway on the hundreds chart. The pathway begins to move down, rather than across as it did with the spins of 1.

Hundreds Chart

1									
11	12	13	14						
			24						
									100

Equations		
1 + 10 = 11		
11 + 1 = 12		
12 + 1 = 13		
13 + 1 = 14		
14 + 10 = 24		



If the students spin a series of 10s, the pathway on the hundreds chart moves down. This allows students to notice the column in the chart, rather than the row.

Hundreds Chart

1									
11	12	13	14						
			24						
			34						
			44						
			54						
									100

Equations		
1 + 10 = 11	24 + 10 = 44	
11 + 1 = 12	24 + 10 = 54	
12 + 1 = 13		
13 + 1 = 14		
14 + 10 = 24		
24 + 10 = 34		

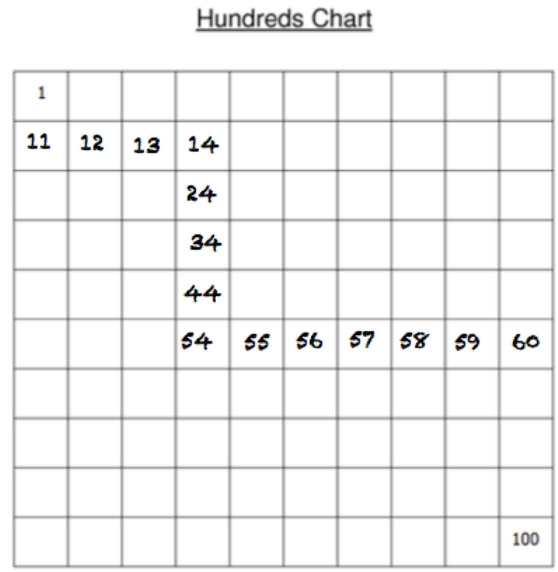
The game ends when students reach 100, exactly, creating a pathway from 1 to 100 on the hundreds chart.

Hundreds Chart

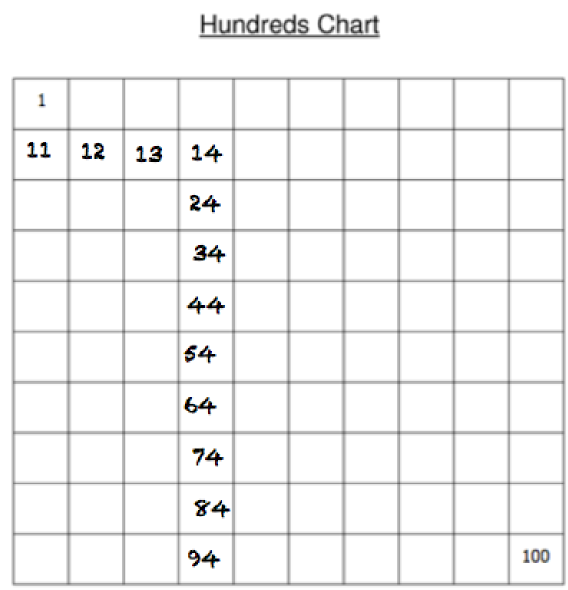
1									
11	12	13	14						
			24						
			34						
			44						
			54	55					
				65	66	67			
						77			
						87	88		
							98	99	100

Equations		
1 + 10 = 11	34 + 10 = 44	67 + 10 = 77
11 + 1 = 12	44 + 10 = 54	77 + 10 = 87
12 + 1 = 13	54 + 1 = 55	87 + 1 = 88
13 + 1 = 14	55 + 10 = 65	88 + 10 = 98
14 + 10 = 24	65 + 1 = 66	98 + 1 = 99
24 + 10 = 34	66 + 1 = 67	99 + 1 = 100

There is one other rule that is in place for this game. This rule states that if the pathway reaches the 10s column, no more spins of 1 can be used. For example, if game play leads the pathway to 60, (see figure to the right) then only spins of 10 can be used to get to 100. This rule allows for students to spin an equal number of tens and ones to create a pathway to 100.[7]



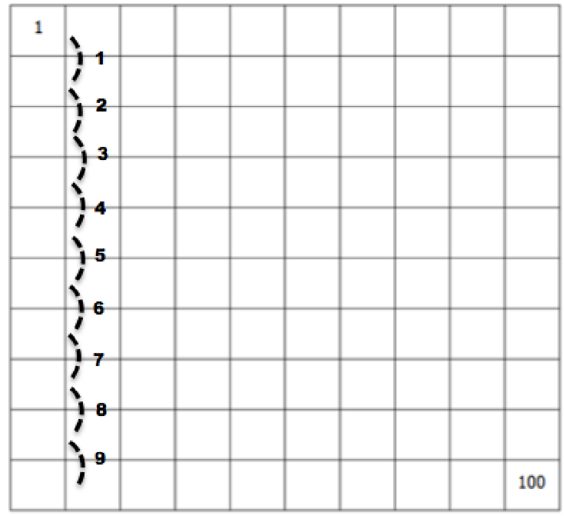
Similarly, if the pathway reaches the last row (which begins with 91 and continues to 100) no more spins of 10 can be used, as this would put the pathway over 100, defeating the game's purpose of reaching 100 exactly. For example, if the pathway reaches 94, (see figure to the right) then only spins of 1 can be used to get to 100.



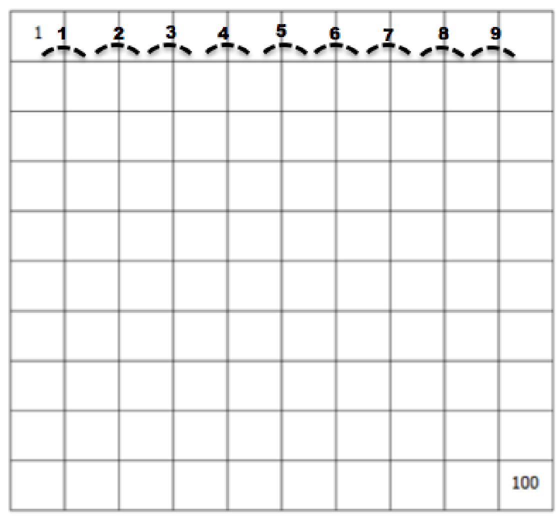
[7] It is important that interns and students have opportunities to discuss the way numbers change when adding a 10 or a 1. If students were able to spin only 1s to get to 100 they would miss out on the opportunities to share thinking and ideas about how adding 10 changes a number and creates number patterns. Additionally, it would take a very long time to get all the way to 100 counting by 1s. So having tens in the mix allows for faster progress.

One more note about the pathway on the hundreds chart; since the rules do not allow students to spin ones after reaching the tens column, students are only able to spin nine 1s during a game, getting them from the ones column to the 10s column (see figure to the right). And, since the rules do not allow students to spin tens after reaching the bottom row of the chart, students are only able to spin nine 10s during a game, getting from the top row to the bottom row of the chart (see figure to the right). This means that every game will have nine spins of 1 and nine spins of 10 for a total of 18 spins. Therefore, there are 18 cells provided in the bottom portion of the game board labeled "equations" to chronicle the 18 spins. Because the game is called "Pathways to 100" play beings at 1 so that the nine spins of 1 (9) and the nine spins of 10 (90) get to 100 (1 + 9 + 90).

Hundreds Chart



Hundreds Chart



The Pathways to 100 game contains specific mathematics that is central to the work of teaching elementary school. Base ten number and operations is content that is likely to be seen and taught by interns in their student teaching placements and future classrooms as K-5 teachers. Rather than focus on any or all the mathematics that can be learned by interns, this game limits the scope of the mathematics that interns and students experience. This limit allows for the teacher education courses to focus on this particular area of mathematics as well as creating a limit on what mathematics interns will be responsible for addressing and managing with students. These limits have a direct impact on my research. First, the limits allow me to more purposefully compare interns across their teaching (e.g., all interns are teaching the same content in the same context). Second, the game allows for authentic unknown events to occur (e.g., each spin is different but comes from a smaller pool of possibilities, a 1 or a 10) that interns must respond to in the moment. The limit of the possibilities allows, again, for logical comparisons across interns and teaching episodes as I track the spins of 1 and 10 as well as the interns' eliciting behavior after each spin. For example, I am able to locate and compare the longer stretches of repeatedly spinning a 1 or a 10 and note the kinds of elicitations interns use across these stretches.

Data Sources

Video episodes. The primary data source for this research is 79 video recordings of twenty-seven interns engaged in teaching the Pathways to 100 game. As mentioned earlier in this chapter, this teaching took place during the third week of the interns' first teaching practicum with elementary-aged students. On average, three teaching episodes were recorded for each intern. Each episode is between 10-15 minutes long. Originally, this data set included 81 episodes of interns' small group teaching. Unfortunately two episodes were removed due to technical difficulties with the video recording device. For these reasons, these two episodes were removed from the data set. Table 3-4 provides a complete picture of the data, indicating intern's episodes by day.

Table 3-4: Description of Intern Teaching Episodes by Day

Name*	Day 11 (Mon.)	Day 12 (Tues.)	Day 13 (Wed.)	Day 14 (Thurs.)	Day 15 (Fri.)	Total
Allison		1	1	1		3
Beth	1	1	1			3
Brooke		1	2			3
Chad			2		1	3
Colin	1		1			2
David	1	1	1	1	1	5
Debbie	2	1		2	1	6
Haley	1					1
Hannah		1	1		1++	2
Henry		1	1		1	3
Kathleen	1		1		1	3
Keith		2	1	1		4
Kendra		2	1		1	4
Kit		1	1	1		3
Maggie		1	2			3
Melanie	1		1		1	3
Mindy		1		1	1	3
Polly		1	1			2
Pricilla		1	1			2
Sandra	1	1		1		3
Stacy		1	1	1		3
Tara	1	1	1			3
Todd	1	1			1	3
Valerie	1		1			2
Veronica		1	1			2
Wendy	1++	1	1			2
Zoe		2		1		3
Totals	12	24	24	10	9	79

*All names are pseudonyms
++ Partial transcript (and video record) since camera shut off mid-episode

Teaching episodes were uploaded to a video storage and organization site called Edthena and were downloaded, by me, to a secure portable drive. All videos used for this research took place during the third week (four in total) of the intern's summer program. Interns recorded themselves teaching using personal video cameras, and then uploaded these recordings to a class website giving access to their university based instructors. This practice of interns' recording and sharing their teaching is routine in this program and allows interns to keep records of their own teaching practice as well as to share their practice with their instructors for course assignments and feedback.

Anecdotal notes and classroom observations. Over the course of the SSP and summer course, I kept a notebook where I jotted down ideas about my teaching and about my interns' learning. Additionally, I kept careful records of the individual intern's teaching episodes as my teacher education colleagues and I observed interns in their practicum classrooms. These notes served as a starting place for my thinking about coding the data as well as grouping interns for comparison. In particular, I noted the practicum classrooms' mentor teachers whom interns observed for the mini lesson and the students whom interns taught during the Pathways to 100 game instruction. My purpose for recording this information about people in classrooms was in case any patterns might emerge regarding these individuals. For example, I wondered if there might be patterns in the mentor teacher's language that interns might take up. Similarly, I wondered if I would find evidence of students using language that was used by interns during small group discussions.

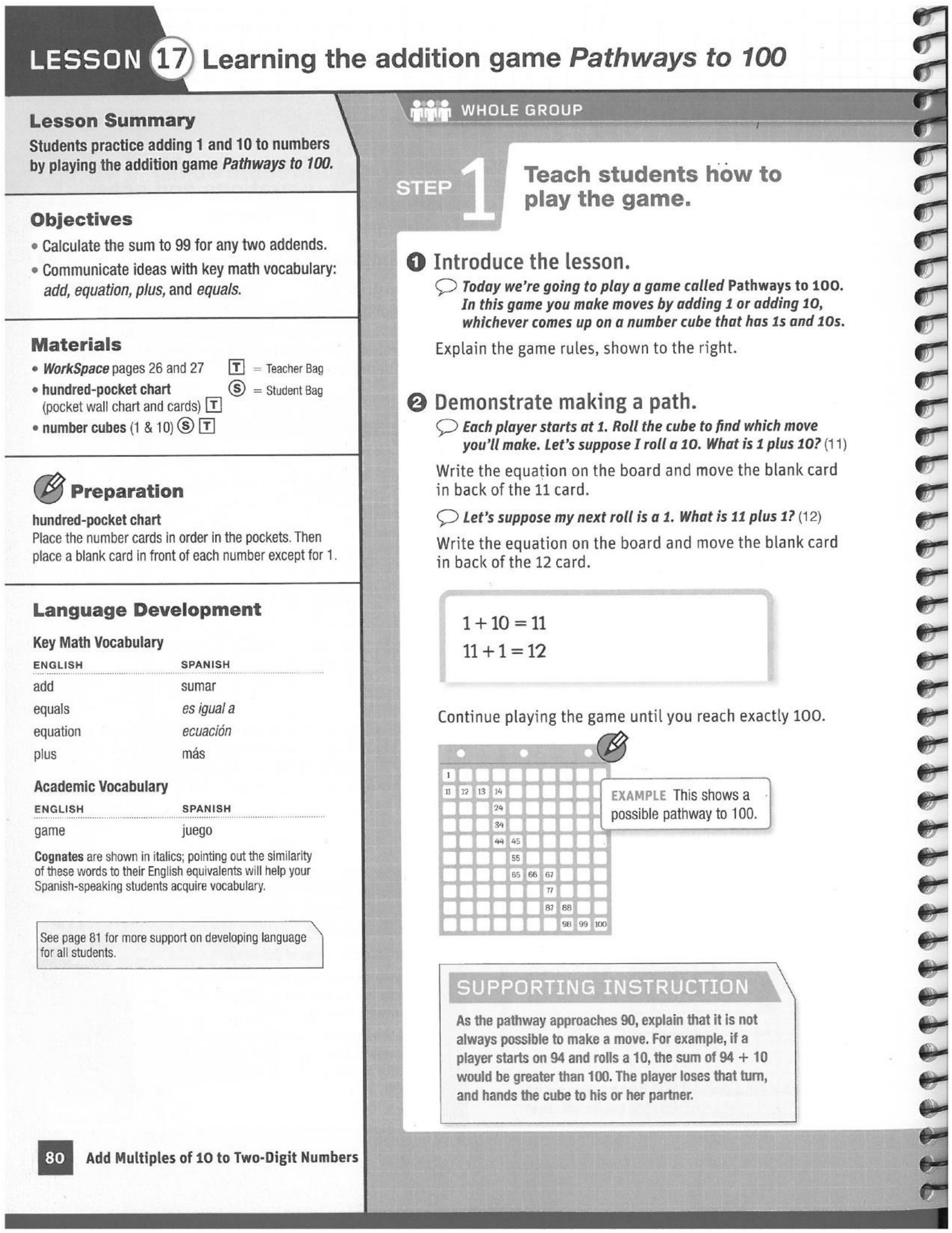
Mathematics curriculum. The secondary data source for this research includes the curriculum that interns used during their small group mathematics instruction. During interns' first week of the course and practicum, the curriculum was highly scripted. Using materials from the *Learning Teaching in, from, and for Practice Project*, course instructors created a script for interns to read, posing specific addition problems to students, in a specified order, and with scripted follow-up questions. A portion of this section of the lesson plan is shown in Figure 3-2. Complete materials provided to interns for week 1 are found in Appendix A.

Enactment	Notes and Cautious Points
Introduce the task (game) to students *Let me see what it looks like when you are all STARs.* (Sit up. Track the speaker.) *Today we are going to play a game called Make Ten. All of you are on one team, and I'm on the other team, all by myself.* *I'm going to deal a <u>ten-frame card</u>, face down, to each of you.* *When I give a <u>silent signal</u>, you will turn over your card.* *I will ask you (1) how many dots you see on your card, (2) how you figured that out, and (3) how many more dots you need to make ten.* *There is one other rule to the game: Everyone else in the group must quietly look at and listen to the speaker while he or she is answering these questions.*	Make sure you have everyone's attention before you begin. Participation goals are incorporated into the rules of the game. Show a card, face up, to students. Decide what your silent signal will be and show it to students.

Figure 3-2: Portion of the Scripted Lesson Plan for Week 1

The curriculum from the second week was also highly scripted. Interns were provided a lesson plan with instructional purpose, mathematical goals, student participation goals, materials list, preparation list, a description of the interns' role in the classroom when not teaching (but observing) and tips for how to manage teaching challenges that might arise (both behavioral and academic). The plan also included a scripted enactment and related notes and caution points to focus and inform the interns' teaching. Complete materials provided to interns for week 2 are found in Appendix B.

For the third week interns were given a single page lesson summary from a published teacher's manual with directions for how to play the game "Pathways to 100." While the teacher's manual page included some scripted teacher talk, this resource was far less scripted than those given during the first two weeks of the program. The single page lesson plan from the teacher manual is shown in Figure 3-3.



LESSON 17 Learning the addition game *Pathways to 100*

Lesson Summary

Students practice adding 1 and 10 to numbers by playing the addition game *Pathways to 100.*

Objectives

- Calculate the sum to 99 for any two addends.
- Communicate ideas with key math vocabulary: *add, equation, plus,* and *equals.*

Materials

- *WorkSpace* pages 26 and 27
- hundred-pocket chart (pocket wall chart and cards) T
- number cubes (1 & 10) S T

T = Teacher Bag
S = Student Bag

Preparation

hundred-pocket chart

Place the number cards in order in the pockets. Then place a blank card in front of each number except for 1.

Language Development

Key Math Vocabulary

ENGLISH	SPANISH
add	sumar
equals	*es igual a*
equation	*ecuación*
plus	más

Academic Vocabulary

ENGLISH	SPANISH
game	juego

Cognates are shown in italics; pointing out the similarity of these words to their English equivalents will help your Spanish-speaking students acquire vocabulary.

See page 81 for more support on developing language for all students.

WHOLE GROUP

STEP 1 Teach students how to play the game.

1 Introduce the lesson.

Today we're going to play a game called Pathways to 100. *In this game you make moves by adding 1 or adding 10, whichever comes up on a number cube that has 1s and 10s.*

Explain the game rules, shown to the right.

2 Demonstrate making a path.

Each player starts at 1. Roll the cube to find which move you'll make. Let's suppose I roll a 10. What is 1 plus 10? (11)

Write the equation on the board and move the blank card in back of the 11 card.

Let's suppose my next roll is a 1. What is 11 plus 1? (12)

Write the equation on the board and move the blank card in back of the 12 card.

$1 + 10 = 11$
$11 + 1 = 12$

Continue playing the game until you reach exactly 100.

EXAMPLE This shows a possible pathway to 100.

SUPPORTING INSTRUCTION

As the pathway approaches 90, explain that it is not always possible to make a move. For example, if a player starts on 94 and rolls a 10, the sum of 94 + 10 would be greater than 100. The player loses that turn, and hands the cube to his or her partner.

Figure 3-3: Teacher Manual Page for Week 3's Pathways to 100 Game (Burns, 2008).

A portion of the interns' homework from the methods course was to script a lesson plan for the Pathways game, like those provided and used during the first and second weeks of the program. Interns were given course time to work with partners and small groups to share and adapt their scripts. Further adjustments and edits were made to lesson plan scripts based on conversations with intern peers and instructors during rehearsals prior to enacting the game with students in their practicum classrooms.

The video records of teaching on which this dissertation is based, are taken from this third week of instruction where teaching interns are engaging students in the Pathways to 100 game. As mentioned earlier in this chapter, interns recorded their own teaching and uploaded these video records to a secure server. I then downloaded these videos for viewing. A paid transcriptionist transcribed all 79 teaching episodes. These transcriptions served as the focus of my analysis.

Data Analysis

In order to investigate my research question, I began with an iterative analysis of the literature and the data to develop a conceptual framework that decomposes the work interns are doing in responding to students' answers during the third turn of talk. These ideas were based on my reading of the literature (as summarized at the end of Chapter 2), my own teaching and teacher education experience, and my anecdotal notes and classroom observations made during data collection (Ryan & Bernard, 2000). In my first stage of analyzing the data I watched all the videos episodes of teaching. This method served three purposes. One purpose was to review and polish each transcript for use in my analysis. I was able to "clean" the transcripts and add notes to aid in my analysis. These notes indicated "unspoken" moments in the teaching such as gestures and the use and movement of materials. I also added question marks to records of speech that were not direct questions (because they did not begin with who, what, when, where or why) but where the speaker's tone of voice, specifically the rising action at the end of speech, indicated an interrogative. I was not sure if these moments would be relevant to my coding and analysis, but decided that including them would give me the option to focus on them if an opportunity presented itself.[8]

The second purpose was to determine a way I might further divide each episode into shorter sections for analysis. I noticed that while viewing the videos I would sometimes stop the video to take a break or finish for the day. Since I was not always able to finish watching a complete teaching episode before stopping the video, and often paused on the video mid-episode. However, I wasn't pausing in just any random place, I was regularly reaching the end of an exchange between intern and students around a single spin. In fact, I was waiting until a new spin occurred in the teaching to pause my viewing. Each new spin created a natural break in the instruction and discussion, and this natural break was made evident by my pausing behavior. My pausing behavior led me to the decision to purposefully divide each teaching episode's transcript into units of analysis by spin.

The third purpose of watching all of the video episodes was to familiarize myself with the data and begin to make informal observations about what I was noticing about the interns and their teaching. I kept a careful log of what I noticed using memos. In particular, my memos reflected my noticing two features of the data: (1) the differing length of the exchanges between

[8] Although I did use these notations in the transcript to parse out turns, I did not end up using them in more purposeful ways across the data. I see this as an opportunity to further investigate this data focusing on intern and student non-verbal communication.

intern and students around one spin in the game and (2) the talk related to mathematics that the interns were using (or not using) in their initial elicitations and responses to student contributions. For example, I found it interesting that many interns used similar, if not identical, language for their initial elicitations. When I also noticed that their third turns of talk varied, I wondered if this was in relation to the correctness of the students' answer. Recall that this was a hypothesis I first presented in Chapter 1. I wondered how I could feasibly, but responsibly compile and compare these differences in interns' follow-up response. It was at this point in my analysis that I decided to focus on the first three turns of talk. I did so in order to compare interns' third turn responses to one another in search of patterns related to student answers and the mathematics of the game.

In the second stage of analysis, I implemented my plan to distill each unit of analysis into the first three turns of talk, which allowed me to see interns as they elicited and then responded to student thinking. Recall the distinct IRE pattern of classroom discourse from chapter 2. I noticed that the first three turns of talk for each episode followed this pattern of teacher initial elicitation, student answer, and teacher response or follow-up. My research question seeks to uncover and describe the patterns of novices' practice of eliciting and responding to student thinking specifically related to (1) the kinds of initial eliciting questions novices seem to pose, and (2) the kinds of responses to student answers novices seem to give. The first three turns of talk allow me to closely examine the initial elicitation and the intern's response to the student answer. At this point, I attempted to apply the four Sleep and Boerst (2012) codes (initial posing, eliciting student thinking, neutral, and leading) to the first and third turn of talk, see Figure 3-4.

Codes for teacher questions.

Type of questions or prompts	Definition	Examples
Category 1: Initial posing		
Initial posing	Initially poses a task or subtask for the student to solve.	*What is 25 + 10?* *How high can you count?*
Category 2: Eliciting student thinking		
Predict	Asks the student to predict the answer before solving the task.	*How many counters do you think there are now?*
Initial elicitation of method/ reasoning	Asks the student to describe the method or reasoning used to solve a task.	*How do you know?* *Can you explain how you did it?*
Probe[a]	Gets the student to further explain her or his thinking.	*And then what do you do next?* *If the child writes 81, show him/her both 81 and 18 and ask: Which is eighteen?*
Explain meaning[a]	Asks the student to explain underlying meaning or rationale.	*Why does that work in this case?* *What do you mean by "it's a ten"?*
Link/apply[a]	Asks the student about connections between mathematical ideas, representations, problems, real life, etc.	*How does what you just did with the sticks fit with what you did on your paper?*
Extend thinking[a]	Extends the situation under discussion to other situations where similar ideas may be used, and/or asks for generalizations or counterexamples.	*Can you think of a different way to count them?* *What would happen if ___?* *Does that method work with any numbers?*
Orient/focus[a]	Focuses the student on key elements or aspects of the situation in order to enable problemsolving.	*How could you be sure?*
Category 3: Neutral		
Revoice/confirm/clarify	Restates the student's response as a question back to the student.	*So what you're saying is ___?*
Repeat/rephrase/reformat	Repeats the previous question, perhaps worded differently or in a different format.	*Let me write the problem down—now can you solve it?*
Check on background knowledge	Asks if the student is familiar with materials, a type of problem, etc.	*Have you ever used these before?*
General description of task	In the task pool: A description of the task is given, but the actual questions are not specified. In interview: A description of the task is given to the student, but no prompts/questions are asked.	*Repeat with 7 in one pile and 10 in the second.*
Category 4: Leading		
Leading[a]	Leading the student through a method or toward an answer.	*You have enough to give everyone one, right?*

Figure 3-4: Codes for Teacher Questions from Sleep and Boerst (2012).

While the initial elicitation, my version of Sleep and Boerst's "initial posing," was fairly straightforward to identify, the third turn proved more difficult to classify. In many cases, it was hard to determine if the intern was eliciting student thinking, providing a neutral response, such as a repetition of what the student had previously said, or if the contribution was leading the student toward a particular method or answer. I began to realize that I needed to focus on the initial elicitation first, and then turn to the third turn of talk. This work comprised the third, fourth, and fifth stages of my analysis. In the following section I will further describe each stage of my analysis and provide examples to further clarify my thinking and rationale during this process.

Investigating research question part 1: initial elicitations. In the third stage of analysis I pulled out all of the turns of talk that were coded as "initial elicitation" so that I could look across all 27 interns for patterns of language and game play. I reviewed 442 initial elicitations across 79 episodes of intern teaching, see Table 3-5.

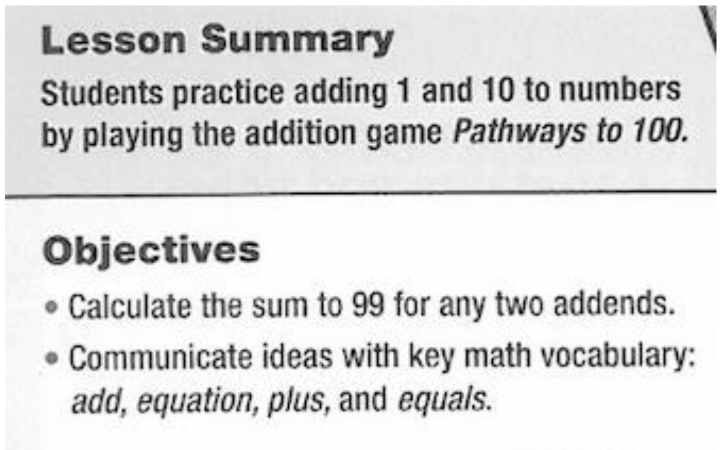
Table 3-5: Description of Initial Elicitations by Day

Intern Name	Number of Episodes	Total number of Initial Elicitations
Allison	3	24
Beth	3	18
Brooke	3	14
Chad	3	13
Colin	2	12
David	5	28
Debbie	6	36
Haley	1	9
Hannah	2	12
Henry	3	10
Kathleen	3	15
Keith	4	15
Kendra	4	29
Kit	3	20
Maggie	3	29
Melanie	3	11
Mindy	3	12
Polly	2	8
Pricilla	2	12
Sandra	3	14
Stacy	3	21
Tara	3	11
Todd	3	22
Valerie	2	14
Veronica	2	10
Wendy	2	12
Zoe	3	11
Total	79	442

I also grouped initial elicitations by intern, looking for specific patterns of language, interactions with students, and mathematics related to game play. First, I investigated patterns of language. I was especially curious about the interns' use of mathematical language and vocabulary. The lesson plan that interns were given to direct their instruction included two learning objectives:

- Calculate the sum to 99 for any two addends.
- Communicate ideas with key math vocabulary: add, equations, plus, and equals.

See Figure 3-5.



Lesson Summary

Students practice adding 1 and 10 to numbers by playing the addition game *Pathways to 100.*

Objectives

- Calculate the sum to 99 for any two addends.
- Communicate ideas with key math vocabulary: *add, equation, plus,* and *equals.*

Figure 3-5: Learning Objectives from Week 3 Mathematics Teaching Curriculum (Burns, 2008).

In light of the second learning objective, I coded for intern use of these "key math vocabulary" words (e.g., equations) to gauge the uptake of the learning objectives in interns' teaching. Next, I attended to intern interactions with students by focusing on turn taking behaviors, specifically, the way in which interns used student names to direct questions and turns of talk. Last, I looked for evidence of interns using numbers in their initial elicitations. I noted the points in these elicitations when interns used numbers to describe the spin, draw attention to the equation, or to the placement on the hundreds chart game board.

Investigating research question part 2: third turn elicitations. In the fourth stage of analysis I focused on interns' third turn of talk. I had hypothesized that interns would respond differently depending on the correctness of students' answers. For example, I wondered if interns would choose *not* to follow-up on incorrect answers because they might see the incorrectness as harder to respond to. I also wondered if the incorrectness would compel the intern to respond to the student, feeling he or she needed to repair the student's misconception. I was curious to see if either of these scenarios would play out in the data and if so, what they would look like in interns' early practice. In order to see this possible effect on intern elicitations and responses, I needed to know the kinds of student "answers" students were giving. To do this I isolated the first three turns of talk: (1) intern's initial elicitation, (2) student's answer, and (3) intern's response to the student. From this set of turns I was able to determine if the student's answer, in the second turn, was correct, incorrect or simply not provided. I looked at the two turns of talk and coded each second turn, the student's answer, as either correct, incorrect or non-response. For example, Chad asks, "98 plus 1 is what?" and Elijah correctly answers:

1. Chad (intern): Oh. So, what is it? 98 plus 1 is what? What is this?
2. Elijah: 99.

Since Elijah answers Chad's initial elicitation correctly, his second turn answer is coded as "correct." In some cases, a student's answer was coded as "correct" even if no verbal contribution was made. For example:

1. Kendra (intern): So let's write the next equation for that one and see if this makes our number pathway look a little different.
2. Amanda: [writes 10 + 34 = 44]

In this case, Amanda does not verbally state the equation that Kendra asks for, but she correctly writes the equation, which is coded as "correct." In sum, if a student provided a correct answer, either verbally or in writing, I coded this second turn as "correct."

An example of a student's second turn answer coded as "incorrect" appears in the exchange between Beth and Shantia:

1. Beth (intern): There you go. Okay, so Shantia now so five plus ten. How much is that?

2. Shantia: That'd be six.

Beth is asking what "five plus ten" equals. Shantia response with, "six" instead of the correct answer of fifteen. Since Shantia's response is not correct, it is coded as "incorrect." In other cases, students may have misinterpreted the question which led them to producing an incorrect response. An example of a misinterpretation occurs between Tara and Nayana:

1. Tara (intern): Okay. So, we spun three tens, right? So we jumped from 70 to 80, one jump of ten, and then we jumped from 80 to 90, and then we jumped to 100 and that's ten. We jumped ten. We jumped ten. And we jumped ten. [*pointing to the hundreds chart*] And then now how many tens did we jump in total?

2. Nayana: Thirty.

In this example, Tara asks, "How many tens did we jump in total?" and Nayana responds with the total number jumped (30) rather than the total number of tens jumped, which is 3 tens. Although Nayana's answer does make sense, given the context of the mathematical task, she is answering a different question than the one Tara posed. Therefore Nayana's second turn answer is coded as "incorrect." In sum, when the student provided a response that did not accurately answer the intern's question, as posed in the first turn elicitation, the student's answer was coded as "incorrect."

Answers coded as "non-response" appeared in one of two ways. First, the student made no verbal or written contribution. For example:

1. Chad (intern): I got something I want to talk about. Look. He said 78 plus 10.

Let’s look right here. What—we’re at 78 and we went to 88. Okay. Why is there an eight in all three of these? Are there?

2. Natasha: [student is silent]

In this exchange, Natasha does not respond to Chad’s question. She offers no verbal or written contribution and from the video record, and no sign of gesture was apparent. The second way students answers were coded as “non-responsive” was if their verbal response was unrelated to the mathematics in any way (e.g., “I like blue; it’s my favorite!”) or if they stated that they “did not know” the answer as Devon does in the following set of turns:

1. Haley (intern): Devon, you're gonna write our equation. So we started at 33 and I want you to demonstrate how we got it.
2. Devon: I don't know.

With the second turns coded for correctness, I was able to analyze the intern’s third turn contributions in relation to (1) their initial elicitation from turn one, (2) the student’s response in turn two, and (3) the correctness of the student’s response from turn two. I again attempted to apply the Sleep & Boerst (2012) codes, this time focusing on questions or prompts that were (1) eliciting student thinking, (2) neutral, or (3) leading. This time, I found greater success in dividing interns’ third turn contributions into one of the three categories. However, I noticed that there were multiple instances where interns did not contribute a third turn. In fact, sometimes no contributions were made after the student’s answer in the second turn of talk. Instead, game play continued with a new spin signaling a new turn. For these cases, where the intern offered no contribution after the second turn of talk, I created a new category coding the intern’s third turn as “no follow-up response.”

In the fifth, and final, stage of analysis, I entered into an iterative process of reviewing my anecdotal notes, the literature, and the codes from Sleep & Boerst (2012) to create more descriptive codes. This process continued until I felt I had fully decomposed interns' third turn contributions. I use the graphic representation in Figure 3-6 to show my thinking and organization of this analysis.

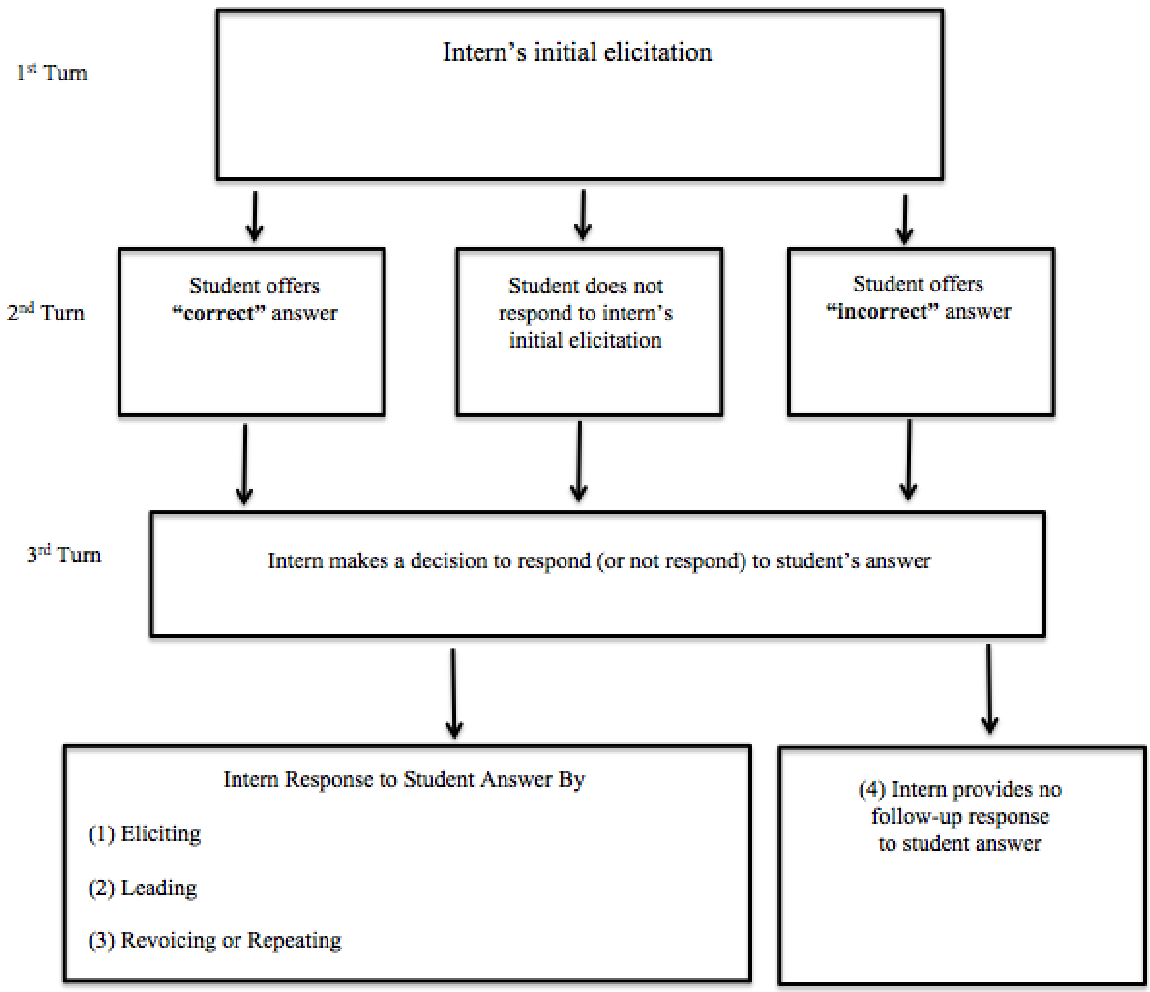


Figure 3-6: Graphic Representation of My Thinking About Coding Interns' 3rd Turn of Talk.

In the end, I developed four root codes: (1) eliciting, (2) leading, (3) revoicing or repeating, and (4) no follow-up response to categorize intern's third turns of talk. I then unpacked each of the first two root codes further, developing sub-codes for both eliciting and leading turns.

For the two larger root code categories, I began by sorting the data according to what I hypothesized to be the intern's intended purpose in their third turn of talk. I used my anecdotal notes, taken during discussion rehearsals and intern teaching episodes, as a resource for supporting my interpretations. For example, I had notes that described a discussion rehearsal where teacher educators and interns engaged in conversation about the value of asking students to make predictions about how far their place on the hundreds chart game board was from 100. These notes allowed me to look at a group of third turns of talk and recognize that interns were eliciting student thinking around making predictions. Similarly, I noticed that interns were regularly referencing three different representations of numbers: (1) the hundreds chart, (2) the spinner, and (3) the equation. All three of these representations were used in the game to represent the sum, addends and calculation (e.g., adding) that are referred to in the first of two learning objectives from the lesson plan, see Figure 3-5.

- Calculate the sum to 99 for any two addends.
- Communicate ideas with key math vocabulary: add, equations, plus, and equals.

Third turn elicitations that referenced one or more of these three representations were coded as "link/apply" as they supported students in linking and applying one mathematical representation to another. The full categorization with descriptions and anchor examples can be found in Table 3-6 below.

Table 3-6: Third Turn Codes with Descriptions and Examples

Turn	Code	Subcode	Description	Examples
1st	Initial elicitation	n/a	First question or direction the intern gives after a spin	•Write the equation. •Yeah. One. Okay. Olivia, what's an equation for adding one? •Okay, what's our equation, Ty?
3rd	Elicitation	Focus on place value	Intern's elicitation focuses on key elements of the task (e.g. place value)	•Go. Why is there an eight in all of these? 68, 78, 88. Why is there an eight? •He said we had nine ten spins. How many one spins did we have?
		Explain meaning	Intern's elicitation asks student to explain their thinking or what they did	•How do you know it's 80? •Why is that? Why do you think? •And Felicia how did you know that is where the 12 went? •How do you get from 33 to 34? •Can you show me how you got there?
		Link/apply	Intern's elicitation connects mathematical representations. Specific mention of the chart or hundreds chart	•So where would this go on the chart? •Ashton, where's 24 going? •Thirty. Did we—and where did we land?
		Consider other's thinking or method	Intern's elicitation asks student to consider, explain, or connect to another's answer, thinking or method of solution Agreement - Intern asks student if s/he agrees or disagrees	•Okay, Evan, I want you to notice that Boaz is doing that. What do you notice about these numbers? 21, 34, 44, 54? •He added 1 to 33, where are we gonna put our answer? •Does anybody think differently? •Okay, Isaak, so Alex wrote 21 plus ten equals 31. Does that look right to you? •22, do you agree Anthony? •71 plus 1 equals 80. Do we—do we agree with that, Modessa?
		Predict	Intern's elicitation asks student to make a prediction, usually about the answer, the next spin or how far to get to 100	•So, what is—what does Makayla need to spin to get to 100? •How many more do we need to get to 100? •Now you guys are getting pretty far, but how many more do we need? •What spins do we need to get to 100? How many?
3rd	Leading prompt	Guide/prompt	Intern is leading student through a method or toward an answer Intern asks a yes/no question Intern is giving information about the procedure or the mathematics in the form of a question	•Are you sure 60's there? •What's our starting number? •Where are we going to put our number? •Plus one? He spun a ten. •Would it be 47?
		Told	Intern gives the answer to the question asked in the initial elicitation	•And then how many we're gonna add to it? One? •Two, right? •Right here. 68 •Isn't it 6 plus 30?

		Management	Intern gives a direction or a command to a student Intern narrates the work or action of the turn Intern's contribution is NOT a question	•Yep, so write your equation. •All right. Darian, it's your turn. •Let's try to put this number first, okay, that way the second number is always our jump, do you get it?
3rd	Revoicing/ repeating	n/a	Intern revoices, repeats or rephrases what a student has said Intern reads aloud or states what a student has written	•You're sayin' 60 plus 7 is 70? •So our equation is 89 plus 10 equals 99. •Equals 88. Do you think you know, or do you know you know? •42? And how did you know it was 42?
3rd	No follow-up response	n/a	Intern does not follow-up with an elicitation No elicitation is made after the student's turn of talk and the game moves on to the next spin	•Okay. Next spin please. •Moving on. Who's turn is it to spin?

Inter-rater reliability. To ensure trustworthiness of the claims, a second researcher coded 15% of the data using the coding schemes. For the third turn coding schemes the two coders reached an inter-rater reliability of greater than 90% agreement and a Cohen's Kappa of .89. This magnitude suggests substantial agreement. In each case of disagreement, the researchers discussed and came to agreement.

Chapter 4

FINDINGS PART 1 – Initial Elicitation

Introduction

In the next two chapters I describe the early eliciting and responding to student thinking practice of interns by focusing on the first three turns of talk, which follow a distinct pattern of discourse similar to Mehan's (1979) Initiate-Response-Evaluate or IRE as described in Chapter 2. In these findings, intern talk dominates the first turn, followed by a second turn contributed by the student. The third turn is the follow-up offered by the intern in response to the student. An example of this pattern is:

1. Intern: What did Emma just spin?
2. Student: A ten.
3. Intern: Okay, so if we start on one, and we're moving ten, where do we put that on our chart?

In this example the intern begins with an initial elicitation, on the first turn asking, "What did Emma just spin?" The student answers the question for turn two, correctly stating, "A ten." Then, the intern follows up by saying, "Okay, so if we start on one, and we're moving ten, where do we put that on our chart?" The intern's third turn, or follow-up, is especially interesting and useful in describing early eliciting and responding to student thinking practice. The third turn is a recurring moment during the mathematics lesson where interns seem most often to respond to the student's contribution and simultaneously move the lesson toward a mathematical learning goal. Because this work is at the heart of learning to teach, it is therefore important to observe and describe in developing practice.

I begin this chapter by defining and giving examples of an initial elicitation as it relates to this dissertation study. I give a larger picture of the data and present my main finding from analysis of interns' initial elicitation. I do so to provide an answer to my first research question: What are the kinds of initial eliciting questions novices seem to pose early on in their preparation? I then go into more detail, describing the three main modes interns employ in the initial eliciting to direct student work and contributions during teaching. I provide examples to further illuminate these modes and frequencies to document their occurrence in intern practice. Finally, I give some context to the work by describing how these findings might be used to support and improve teacher education and intern practice.

Initial Elicitation

The intern's initial elicitation is the first turn of talk made by the intern directly after the spin during game play. An elicitation is a request of students made by the teaching intern. Some initial elicitations take the form of a direct question, requiring a student to respond verbally. In the example on the previous page, "*What did Emma just spin?*" the intern asks the student to respond with the number for the spin that just took place. Some initial elicitations take the form of a direction or command, instructing the student to do a particular task related to the place value game that serves as the vehicle for mathematics instruction during these small group teaching episodes. For example, "Write the equation," is a direction the intern gives expecting the student to respond by writing the equation for the spin.

The initial elicitation is important for two reasons. First, it gives context to the second turn, the student's answer or reaction to the initial elicitation. It also frames the third turn, which is the intern's follow-up to the student's answer. For example:

1. Veronica (intern): Nyeem, can you write the equation down here?

2. Nyeem: Wait, okay, it would be 22 + 10 = 32. [*student writes the equation as he says it aloud*]

3. Veronica (intern): Kenya, can you put 32 in this chart where you think it should go?

Veronica's initial elicitation about the equation is directly connected to Nyeem's answer, which is given in the form of the spoken and written equation. Then, Veronica's follow-up elicitation asks Kenya, a second student, where the sum of the equation, 32, should be placed on the hundreds chart. If we did not know that Veronica asked about the equation in the first turn, and that Nyeem gave the equation with the sum of 32 in the second turn, it might appear that Veronica is giving the answer of 32 away, when in fact, she has elicited this sum from Nyeem and then elicited the placement of the sum on the chart from Kenya.

Second, the initial elicitation guides the communication, both spoken and written, that takes place during the episode. It directs the way in which students will be communicating, by indicating whose turn it is to record or speak. It also directs the content of those communications by drawing attention to particular mathematical vocabulary to be spoken and specific numbers and symbols that need to be recorded. For example:

1. Alison (intern): Okay, so what's our equation Olivia? We ended on 31, we're adding 20.

In this example, Alison is directing a particular student, Olivia, to do the work of recording the equation in writing. She uses specific mathematics vocabulary, the word equation, as part of her initial elicitation, which is aligned with the learning objectives for this lesson. She further uses numbers that relate to the spin, 20, the current position on the number chart, 31, and the word "adding" to guide Olivia's work in writing the number sentence 31 + 20 = 51.

Main Finding

The main finding from my analysis of interns' initial elicitations is that they are directing students' oral and written contributions in meaningful ways, but not on a consistent basis. I found instances of purposeful use of mathematical language by interns. For example, Kendra uses the term "add" in her initial elicitation:

1. Kendra (intern): We need an equation, so think about where did we leave off and what are we gonna add?

Kendra uses the term "add" to support her students in writing an equation for the spin of the game. In fact, Kendra uses the term "add" in three of her initial elicitations during a single teaching episode. However, she is not using the term consistently. For the two total episodes of Kendra's teaching that I reviewed for this dissertation, I found that she used "add" in only one of the two episodes. Further, she poses 29 initial elicitations across the two teaching episodes and only three of these 29 episodes include the word "add." This means that Kendra used "add" about 10% (3/29) of the time she posed an initial elicitation. Although Kendra is using specific mathematical terminology, such as "add," she is using it inconsistently. This pattern of use without consistency was found for many interns across all three modes of directing students' oral and written contributions. In the following sections, I will dig into the modes of directing student contributions and provide more examples of this pattern of inconsistency in the interns' initial eliciting practice.

4 modes of directing students' oral and written contributions during game play. In reviewing interns' initial elicitations, I became aware that at a whole, these elicitations served the purpose of directing as much as eliciting student thinking and work. I noticed that the questions interns were posing in their initial elicitation were actually telling students what to do to facilitate game play. For example,

1. Keith (intern): We're starting at 31 and we add 30, so where would that take us on the chart?

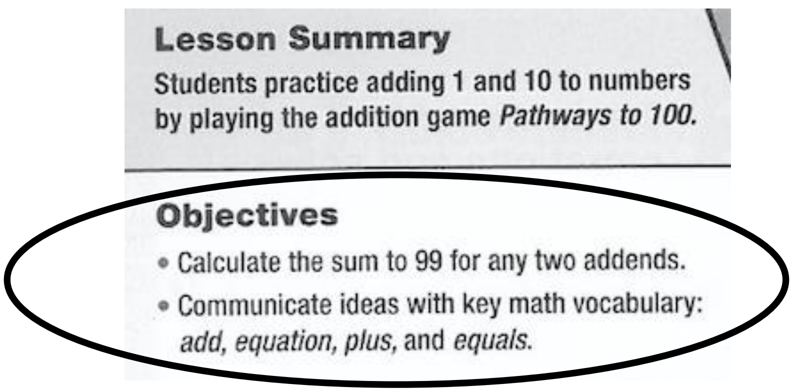
Although Keith is asking the question, "where would that take up on the chart," he is simultaneously providing information about the equation by stating the starting place at 31 and the need to add 30. Using a question while also providing information serves to direct students through the process of creating the expression 31 + 30. His direction has led students toward the sum of 61, which is the position on the chart, or answer, to the question he asked. Keith's initial elicitation is like many of his fellow interns in this cohort. There are other examples of interns using a question, along with giving information, to direct students' oral and written contributions. In the three examples below, each intern uses multiple sentences in her initial elicitation. In each case, one sentence is a question while the others are statements that give information that directs students' contribution to game play.

1. Haley (intern): Ten, so, you're gonna write on our chart 13 plus 10 more. Where's that gonna go?

1. Sandra (intern): Ashton spun a one. What would you write for that equation? We started with a two.

1. Valerie (intern): Okay, we got a ten that time. All right, Delaun, if we're at 78 and we add ten what space are we going to end up in?

From the example, you can see that Haley uses her first sentence to direct the student in writing 13 + 10 on the chart. Then, in her second sentence she asked the question, "Where's that [sum] gonna go?" Similarly, Sandra provides two sentences with information: the spin of one and the starting place of two. The other sentence is a question, "What would you write for that equation?" Valerie's initial elicitation is a little bit different. She uses one sentence to give information about the spin of 10, but in the other sentence she asks the question, "What space are we going to end up in? she also provides more direction related to the starting number, 78 and restates the spin of ten. Although different, Valerie's initial elicitation is doing the same work of directing student contributions as in Haley, Sandra and Keith's initial elicitations. Noticing this pattern of directing student contributions got me to thinking about the objective of this lesson. How might interns' initial elicitations give me insight into their interpretation of the lesson objectives? I turned to the learning objectives from the teacher manual page that served as the lesson plan for week 3. It appears in Figure 4-1, below.



Lesson Summary

Students practice adding 1 and 10 to numbers by playing the addition game *Pathways to 100.*

Objectives

- Calculate the sum to 99 for any two addends.
- Communicate ideas with key math vocabulary: *add, equation, plus,* and *equals.*

Figure 4-1: Lesson Summary (Burns, 2008).

From this curriculum I noticed that both "calculate" and "communicate" are listed as learning objectives. Interns were, in fact, directing their students, if not leading them through, the work of calculating and talking through the equations for each spin of game play. I wondered if there were different ways or modes that interns were directing student contributions. I
began to group interns' initial elicitations based on the kinds of math terminology, or "math vocabulary" as it is termed in the lesson plan objectives. I found that I had some initial elicitations that did not fall into this category of "math vocabulary" use. When I looked for other

commonalities in language, I noted that in many cases interns were using student names in their initial elicitations. As I pooled these examples together, I noticed that interns were using names to indicate game turns. They named who had just spun and who was to write the equation or place the sum on the game board. This pattern led me to call this second category turn taking, because the use of names in the initial elicitation was supporting interns in directing turn taking during game play.

The remaining initial elicitations that had not fit into the first or second category were placed in their own group. The category felt like a 'catch-all' so I decided that I was too involved with this data to see a meaningful pattern and need a more objective eye. I decided to share the initial elicitations from this 'catch-all' category with three different education colleagues. I asked each what she noticed about this group and if any similarities or patterns were evident. All three women noted the way intern initial elicitations served to narrate or talk through the work of writing the equation or finding the sum and locating its position on the game board. One called this work "leading game play." I decided to use her words, game play, for the third category. In sum, I determined that the interns in this cohort employ three specific modes in their initial elicitations to direct student contributions: (1) mathematical terminology (2) turn taking, (3) game play, and (4) using numbers. I will describe each mode in greater detail in the following sections as well as provide examples of each mode from the data.

Mathematical terminology. In this section I describe the specific mathematical terms that interns use in their initial elicitations. I purposefully chose these terms based on the lesson plan learning objectives listed in Figure 4-1. Initially, I had included all four terms that appear in the learning objectives: add, equation, plus and equals. During my analysis of the teaching episodes transcript, I found so few instances of the word "equals" that I decided this term was not worth investigating for the purposes of understanding interns' initial elicitations. I could have chosen to explore why "equals" was not as present in the initial elicitations, but I decided instead to focus my analysis on the three remaining mathematical terms: add, equation and plus. Knowing that the terms "add" and "plus" are often used together and described as the same mathematical symbol (+), I decided to investigate these two terms together and as such, findings and examples of "add" and "plus" are captured in the same section of this chapter. In the following sections I begin by detailing interns' use of the term "equation" in their initial elicitations, as well as the terms "add" and "plus." I then turn to interns' use of numbers (e.g., naming the number on the spinner or naming the starting place on the chart) before moving on to a new mode of directing students' oral and written contributions during game play.

Using the term "equation." One of the primary tasks of the Pathways to 100 game is to write equations that describe or record the spins that occur during game play. I was interested to see how frequently interns were using the term, "equation" in their work with students. I found that in about 30% of their initial elicitations (137/442) interns used the term "equation". For example, "What's our equation?" and "Write the equation," were common initial elicitations that included the word "equation." Upon further investigation of the initial elicitations, I noticed that Sandra did not use the term, "equation" but instead used a similar phrase, "number model," in her initial elicitations.

1: Sandra (intern): What would you write for that number model?

In fact, Sandra was not the only intern who used the phrase, "number model." Four other interns used the phrase "number model" in their initial elicitations:

1. Hannah (intern): So we're gonna go—we're gonna go there, and Aaron, can you write your number model?

1. Polly (intern): All right. So, now, you get to write our number model.

1. Kathleen (intern): So where's our path gonna go next? Here, here, here, here? Show me. If we're at 94 and Camaya just spun a one—I don't know. So Camaya, Nate just wrote a 95 next to 94. Can you write a number model that shows me why he did that?

1. Keith (intern): He got a ten. Okay, so Louis, where—actually, let's do it this way. If we start at one and we get—add ten more, what's a number model that we can write for that, okay?

Interestingly, of the five interns who used the phrase, "number model" four of them did not use the term "equation" at any point in their initial elicitations. This finding made me wonder if they were replacing the term "equation" for the more kid-friendly "number model." I was curious to see where the interns may have learned this phrase. It may have been said in our pre-teaching rehearsals, but I know that as teacher educators, we purposefully used the term "equation" and supported interns in using this during class time and rehearsals. I wondered where else interns may have heard this language. This thought made me consider their time spent in classrooms with students and mentor teachers. When I looked back at my anecdotal notes from the SSP, I found that Keith, Hannah and Sandra were in the same classroom with Mr. Jordan as their mentor teacher, and Kathleen and Polly were in the same classroom with Ms. Taylor as their mentor teacher. It is likely that both Mr. Jordan and Ms. Taylor used the phrase "number model" during the mini lessons that interns observed before their small group teaching episodes.

After noting that a few interns used alternative language in place of "equation" I searched the initial elicitations transcripts for other words or phrases that may have been substituted for the word “equation.” I found that Debbie used the phrase, “number sentence” in 18 of her 36 initial elicitations, or half of the time. For example:

1. Debbie (intern): Good spin. Ten. All right. Okay, so we’re at—gotta write your number sentence. We’re at 24 and we need to add 10.

Debbie had not used the term “equation” in any of her 36 elicitations, so it seemed plausible that she was replacing “number sentence” for “equation” in her initial elicitations. When I went back to my anecdotal notes once again, I noted that Debbie was in Ms. Kent’s classroom. I examined the elicitations of the other interns who had also been in Ms. Kent’s classroom and found that one, Chad, did not use the term “equation” or any other phrase in place of it. Tara used the term “equation” very little in her initial elicitations, only twice in eleven total initial elicitations, while Veronica was a consistent user of the term “equation.” The term showed up in 80% of her initial elicitations. So there was a marked lack of consistency in the language around “equation” for the interns who were in Ms. Kent’s classrooms.

Using the terms “add” and “plus.” One of the lesson objectives for the Pathways game is to communicate using key mathematics vocabulary. Two of these key mathematics terms are “add” and “plus.” 70% of interns (19/27) used the term “add” at least once in their initial elicitations. However, the term “add” only appeared in 12% of all intern initial elicitations. The large different between 70% and 12% is indicative of interns using the term, but using it rarely. In fact, almost 93% of interns (25/27) used the term “add” in 3 or fewer of their initial elicitations, and most (26/27) used it in fewer than half of the initial elicitations they posed. Similarly, 67% of interns (18/27) used the term “plus” at least once in their initial elicitations, but they used the term very sparingly, in only 11% of all their initial elicitations. See Table 4-1 for a more comprehensive picture of the data.

Table 4-1: Intern Use of the Mathematical Terms “Add” and “Plus” in Their Initial Elicitations

Intern	Total Initial Elicitations	Use of the Term "add"		Use of the Term "plus"	
	n	**n**	**%**	**n**	**%**
Todd	22	0	0	0	0
Henry	10	0	0	0	0
Veronica	10	0	0	0	0
Mindy	12	0	0	1	8
Zoe	11	0	0	1	9
Wendy	12	0	0	2	17
Kit	20	0	0	5	25
Brooke	14	0	0	4	29
Beth	18	1	6	10	56
Kathleen	15	1	7	0	0
David	28	2	7	5	18
Chad	13	1	8	3	23
Melanie	11	1	9	1	9
Tara	11	1	9	2	18
Stacy	21	2	10	0	0
Maggie	29	3	10	1	3
Kendra	29	3	10	2	7
Allison	24	3	13	3	13
Sandra	14	2	14	1	7
Colin	12	2	17	0	0

Hannah	12	2	17	1	8
Valerie	14	3	21	0	0
Polly	8	2	25	0	0
Debbie	36	9	25	2	6
Pricilla	12	3	25	3	25
Haley	9	3	33	3	33
Keith	15	8	53	0	0
Total	**442**	**52**		**50**	
Percent		12		11	

The fact that interns are using only two key mathematics vocabulary terms is problematic, especially when considering that these two terms are two of only four total key terms that the lesson plan prescribes teachers and students to use when communicating during the Pathways game. More broadly, the narrating of numbers and the mentioning of operators such as "plus" or "adding" in the initial elicitation demonstrates the interns' uptake of the learning objectives for this lesson. If interns are not taking up the vocabulary listed in the lesson objectives, then they are not effectively taking up the lesson objectives. This tendency means that teacher educators have a greater responsibility to direct interns to the learning objectives in the curriculum and to support their planning and teaching to reflect these objectives.

Using numbers. Interns used numbers for their initial elicitations in two ways: (1) in restating the spin, and (2) in naming the starting position for the equation, which is also the location on the Hundreds Chart. 100% of the interns named the spin in at least one of their initial elicitations. In fact, 53% (223/442) of all intern initial elicitations included a restating of the spin. For example, Melanie restates the spin of ten in her initial elicitation:

1. Melanie (intern): Okay. Um, Zach, I think it's your turn [to write the equation]. We got another ten. We are doing big chumps-jumps on our hundreds chart. Emma spun a ten.

Similarly, David restates the spin as the first word of his initial elicitation, saying,

1. David (intern): Twenty. All right, so, Ashton, can you write our equation please?

In the cases of both Melanie and David, the intern is drawing the students' attention to the spin so that they are able to use the number of the spin to write the equation.

93% of the interns (25/27) named the starting position for the equation in at least one of their initial elicitations, and 28% of the total number of initial elicitations (125/442) included the number of the starting position for the equation. For example, Stacy names the starting position for the equation in her initial elicitation saying, "We're at 89."

1. Stacy (intern): All right, so where are we headed? We're at 89.

She is naming the location where the group is on the Hundreds Chart game board, and the first addend of the equation. In a similar way, Sandra narrates the turn by naming both the spin, one, and the starting number, two.

1. Sandra (intern): Ashton spun a one. What would you write for that equation? We started with a two.

In fact, 89% of interns (24/27) used both the number of the spin and the starting number in at least one of their initial elicitations, see Table 4-5.

Table 4-2: Intern Use of "Spin" and Naming the Starting Point to in Their Initial Elicitations to Narrate the Turn

Intern	Total Initial Elicitations	Names Spin		Names Starting Point		Names Both Spin & Starting Point	
	n	n	%	n	%	n	%
Henry	10	1	10	0	0	0	0
Wendy	12	3	25	1	8	1	8
Todd	22	6	27	1	5	0	0
Maggie	29	8	28	4	14	3	10
Kit	20	6	30	3	15	3	15
Melanie	11	4	36	5	45	3	27
Veronica	10	5	50	0	0	0	0
Allison	24	11	46	7	29	6	25
Kendra	29	14	48	4	14	4	14
Colin	12	7	58	3	25	3	25
Mindy	12	3	25	5	42	2	17
Zoe	11	5	45	2	18	1	9
Hannah	12	7	58	2	17	2	17
Debbie	36	20	56	13	36	13	36
David	28	17	61	8	29	7	25
Stacy	21	13	62	3	14	3	14
Brooke	14	7	50	7	50	4	29
Valerie	14	11	79	4	29	4	29
Kathleen	15	12	80	8	53	8	53
Tara	11	6	55	5	45	4	36

Beth	18	10	56	8	44	6	33
Chad	13	5	38	6	46	2	15
Polly	8	7	88	2	25	2	25
Haley	9	8	89	2	22	2	22
Pricilla	12	11	92	5	42	5	42
Sandra	14	11	79	6	43	4	29
Keith	15	15	100	11	73	11	73
Total	**442**	**233**		**125**		**103**	
Percent		53		28		23	

When interns restate the spin and name the starting position for the equation, they are drawing their students' attention toward the essential mathematics that are needed for doing the work of writing the equation, which serves as one of the primary learning goals for playing the Pathways game.

Turn taking. As described in Chapter 3, the work of playing the Pathways to 100 game consists of three tasks: (1) spinning a spinner, (2) recording the equation for the spin, and (3) placing the equation's sum on the Hundreds Chart. In order to organize game play interns employ turn taking whereby they define the turn and direct students in the work of doing each of the three tasks. For example, Allison uses a student's name, Eddie, to indicate that he will give, or write, the equation.

1. Alison (intern): So, Eddie, what's my equation?

By using Eddie's name, Allison is orienting him to the work, and signaling that the other students are not meant to give the equation. Likewise, other interns used student names to indicate whose turn it was to do the work of the game. Some examples include:

1. Henry (intern): What's our equation, Bashir?

1. Kendra (intern): All right, Lara got a 1. So Skylar I'm comin' to you. Can you write the equation that's gonna go with it? It's gonna come in down here. We're starting at 1.

1. Valerie (intern): Ten. All right, oh, Delaun, we're gonna let Delaun do some writing.

1. Zoe (intern): Okay, all right how far did we get today? Derrick, how far did we get today?

In fact, 93% (25/27) of interns used student names in their initial elicitations. See table 4-2 below.

Table 4-3: Frequency with Which Interns Use a Student's Name in Their Initial Elicitations

Intern Name	Total teaching episodes	Total initial elicitations	Use of Student Names	
		n	**n**	**%**
Allison	3	24	7	29
Beth	3	18	4	22
Brooke	3	14	1	7
Chad	3	13	4	31
Colin	2	12	5	42
David	5	28	12	43
Debbie	6	36	8	22
Haley	1	9	2	22
Hannah	2	12	7	58
Henry	3	10	4	40

Kathleen	3	15	10	67
Keith	4	15	13	87
Kendra	4	29	8	28
Kit	3	20	1	5
Maggie	3	29	5	17
Melanie	3	11	7	64
Mindy	3	12	5	42
Polly	2	8	3	38
Pricilla	2	12	9	75
Sandra	3	14	10	71
Stacy	3	21	3	14
Tara	3	11	0	0
Todd	3	22	0	0
Valerie	2	14	12	86
Veronica	2	10	7	70
Wendy	2	12	2	17
Zoe	3	11	6	55
Total	**79**	**442**	**155**	

To summarize, specific names of students (e.g., Eddie or Bashir) were used to indicate whose turn it is to participate in the work of spinning, of answering questions and of writing on the game board, and to signal the end of one turn and the start of a new turn. Interns used names to direct students' attention and contributions to game play. Interns may also have been using student names to make their initial elicitations personal. Perhaps students feel more compelled or excited to participate if their teacher used their name. Does asking, "Derrick, how far did we get today?" really differ from "How far did we get today?" Is Derrick more likely to be engaged and share his thinking if the question includes his own name?

Game play. In this section I detail the ways in which interns directed students in playing the Pathways to 100 game. I noticed a regular occurrence of particular words in this category of initial elicitations. Those words were, "write," "spin," "chart," and the use of specific numbers 1 through 100. I began to wonder what it was about these words that made them occur more regularly, and why might they occur together in an individual initial elicitation. I realized that these words were not especially specific to mathematics, but rather were specific to the mathematics task of the game. In order to direct the work of the game, which includes the work of spinning a spinner, writing equations, and plotting numbers on a hundreds chart, interns were using words like 10 and "chart" to support students in playing the game. This group, which had been originally called the 'catch all' category, now made greater sense to me as directing game play. There were three ways in which interns directed game play during their teaching episodes: (1) using the word "write," (2) using the word "chart," and (3) using numbers. The first, using the word "write," is significant because it narrates a specific task or action to be done by the student. During the SSP interns were encouraged to support students in doing the work of the game. As teacher educators, we had discussions with our interns about allowing students to hold the writing utensil and not taking a pencil or pen from a student's hand. Additionally, we supported interns in positioning materials in front of students and eliciting students' physical engagement with the game board and spinner during pre-teaching rehearsals. For this reason, it made sense that interns would use the word "write" to direct students in the work of the game.

The second way in which interns directed game play during their teaching episodes was using the word "chart." It drew students' attention to one of the representations of numbers that is foundational to game play, the hundreds chart game board. In their initial elicitations interns used the word "chart" to orient students to the game board and the position of the starting place (first addend in the equation) or the equation's sum.

The third way interns direct game play is through their use of numbers. This third way is directly related to the first two ways in that the work of writing the equation or writing on the chart requires the use of numbers. Spinning also draws attention to numbers as there are a specific set of numbers on the spinner that are then used in writing the equation. In this way, numbers connect the writing of the equation and the position of the chart. In light of this connection, it makes sense that interns would use numbers in their initial elicitations to direct student contributions during game play.

Using the word "write." One way interns directed game play and student participation during the teaching episode was by using the word "write" in their initial elicitations. In fact, about 30% of interns' initial elicitations (137/442) included a request or direction to write the equation on the game board. For example, "What's our equation?" and "Write the equation," were common initial elicitations that included the word "equation." In fact, when interns used the word, "equation" 65% of them also used the word, "write." This makes sense since one of the main tasks of the game is to write an equation in the space below the hundreds chart on the game board. Some of the different elicitations that included both, "equation" and "write" are listed below:

1. Beth (intern):	Yes. Okay. So write in the equation. What would it be?
1. Brooke (intern):	So is it—it's your turn to write the equation. What was our number?
1. Kit (intern):	So write the equation.
1. Melanie (intern):	Zach, your turn to write the equation.

1. Todd (intern): Yeah. Okay. So write the equation for me. So where do we start at?

1. Zoe (intern): Derrick, write our equation.

1. Mindy (intern): Why don't you write right there our equation? What do you think you should write?

It is interesting to note that some interns say, "write *the* equation" while others say, "write *our* equation." I wondered if this different between "the" and "our" is an intern's attempt to create ownership on the part of the group or the student. The issue of ownership makes me think about a point I made earlier in this chapter about making the work personal by using student names. Might using "our" be another way in which interns are making the work of game play more personal for students?

In looking at interns individually, I found that 70% (19/27) used the word "equation" in their initial elicitation. The remaining never referred to equations. When I grouped interns by their frequency of initial elicitations that included the word "equation" I found that interns fall into three fairly distinct groups: (1) using the word "equation" 50% or more of the time, (2) never using "equation" at all, and (3) using the word "equation" less than 50% of the time. For example: Alison posed 24 total initial elicitations. Of those 24, she used the word "equation" in 21 of them, or about 88% of the time. Similarly, Henry posed 10 total initial elicitations. Of those 10, he used the word "equation" in 7 of them, or 70% of the time. Since interns in this group used the word, "equation" in 50% or more of their initial elicitations I am calling their use "regular." A total of 9 interns (or 33%) fell into this category regularly using the word "equation" in their initial elicitation. In contrast, there are 30% (8/27) of interns who did not use "equation" in any of their initial elicitations. For example, Valerie posed 14 total initial elicitations. Of those 14, she used the word "equation" in 0 of them, or 0% of the time. Those interns who fell into the middle group of 10 interns (or about 37%), used the term “equation” irregularly, ranging from 8% usage to 46% usage. Since this group used the term less than 50% of the time, I am calling their use irregular. See Table 4-3.

Table 4-4: Intern Use of the Words “Equation” and “Write” in Their Initial Elicitations

Intern Name	Total initial elicitations	Uses the term “equation”		Use both “equation” and “write”		Use the word “write” but NOT the word “equation”	
		n	%	n	%	n	%
Chad	13	0	0	0	0	2	15
Debbie	36	0	0	0	0	7	19
Hannah	12	0	0	0	0	4	33
Kathleen	15	0	0	0	0	2	13
Keith	15	0	0	0	0	5	33
Maggie	29	0	0	0	0	1	3
Polly	8	0	0	0	0	1	13
Valerie	14	0	0	0	0	4	29
Colin	12	1	8	0	0	3	25
Haley	9	1	11	1	11	2	22
Stacy	21	3	14	2	10	1	5
Tara	11	2	18	2	18	1	9
Kit	20	5	25	2	10	2	10
Mindy	12	3	25	3	25	4	33
Wendy	12	4	33	3	25	4	33
Beth	18	7	39	7	39	1	6

Melanie	11	5	45	4	36	0	0
David	28	13	46	12	43	4	14
Brooke	14	7	50	4	29	0	0
Kendra	29	15	52	10	34	0	0
Todd	22	12	55	11	50	4	18
Pricilla	12	7	58	5	42	2	17
Sandra	14	9	64	6	43	3	21
Zoe	11	7	64	6	55	0	0
Henry	10	7	70	2	20	0	0
Veronica	10	8	80	7	70	0	00
Allison	24	21	88	1	4	1	4
Totals	**442**	**137**		**88**		**58**	
Percent		31		20		13	

Interestingly, in about 60% (88/146) of the cases where interns used the word, "equation" they also used the word, "write." This seems to demonstrate that in general, when interns used the word equation more frequently they were then also more likely to use the term, "write." However, in 40% of cases interns used the directive, "write" but did not use the term, "equation." For example,

1. Mindy (intern): Twenty. Okay. Where are you gonna put that? And what number are you gonna write?

1. Kathleen (intern): You write it. Where does it go?

1. Wendy (intern): Since we already know what it is, can we just write it in?

1. Chad (intern): Here you go. Write it up here.

1. Colin (intern):	Okay, what do we write?

1. Haley (intern):	Do you wanna write where that would go on our chart?

1: Sandra (intern):	What would you write for that number model?

It appears that in many of these cases, the intern is directing the student to write, but not necessarily to write the equation in the equation section of the game board. Perhaps the intern is directing a student to write the number on the Hundreds Chart portion of the game board. This makes sense given what Haley says:

1. Haley (intern):	Do you wanna write where that would go on our chart?

In this initial elicitation, Haley makes specific mention of the "chart," directing the student to place the number on the Hundreds Chart, rather than write the equation. I began to wonder, are some interns using the word "write" exclusively for the purpose of writing the equation, or are they using the term "write" for any written contribution students make during game play?

Using the word "spin." A second way interns directed game play and student participation during the teaching episode was by using the word "spin." For example:

1. Zoe (intern):	Where is it on our number chart? Derrick. What did you spin?

Like Zoe in this example, the majority of interns (24/27) used the word "spin" in at least one of their initial elicitations. However, all but 1 or 96% of interns used the word "spin" in fewer than half of their initial elicitations. This variation demonstrates a pattern of use across interns but without consistency. Although interns seem to be capable of using the term "spin" to direct student contributions and game play, they are not using it with frequently or consistently.

Table 4-5: Frequency with which Interns Use Words Related to the Pathways to 100 Game in Their Initial Elicitations

Intern	Total Initial Elicitations	Use of the word "spin"		Use of the word "chart"	
	n	n	%	n	%
Allison	24	8	33	0	0
Beth	18	1	6	2	11
Brooke	14	0	0	0	0
Chad	13	6	46	3	23
Colin	12	2	17	0	0
David	28	2	7	2	7
Debbie	36	7	19	0	0
Haley	9	0	0	7	78
Hannah	12	3	25	9	75
Henry	10	1	10	1	10
Kathleen	15	8	53	1	7
Keith	15	6	40	3	20
Kendra	29	6	21	10	34
Kit	20	0	0	0	0
Maggie	29	5	17	0	0
Melanie	11	2	18	1	9
Mindy	12	2	17	0	0
Polly	8	1	13	0	0
Pricilla	12	3	25	3	25
Sandra	14	5	36	1	7

Stacy	21	2	10	0	0
Tara	11	2	18	4	36
Todd	22	2	9	1	5
Valerie	14	5	36	0	0
Veronica	10	2	20	2	20
Wendy	12	2	17	0	0
Zoe	11	3	27	3	27
Total	442	86		53	
Percent		19		12	

Using the word "chart." A third way that interns directed game play and student participation during the teaching episode was by including the word "chart" in their initial elicitations. In about 12% of their initial elicitations interns used the word "chart" to draw students' attention to the mathematical representation of the hundreds chart that serves as the game board, see Table 4-3. For example:

1. Hannah (intern): One. All right, where's that gonna go on our chart?

While some interns, like Hannah, used the word "chart" in 75% of her initial elicitations, 41% (11/27) of interns never used the word "chart" in their initial elicitations. Further, the majority of interns (24/27) used the word "chart" in less than 30% of their initial elicitations, again showing an over all occurrence with out consistency. When comparing the use of the words "spin" and "chart" it appears that interns use "spin" more frequently in their initial elicitations than they do "chart." This may be due to the fact that a spin occurs during each turn and that spin, the number spun, is one of the addends in the equation students write on the game board. I noticed that interns frequently use the word "spin" for both of these purposes: (1) to name the spin, and (2) to recall the spin so that it could be used in writing the equation. For example, Pricilla uses the word “spin” to name the spin that has just occurred during game play:

1. Pricilla (intern): Oh, we spun a ten. All right, so, Isaak, I’m gonna ask you. Can you write an equation that shows what happens?

Chad also uses the word “spin” but in this example he is using “spin” to recall the spin of 1 that has just occurred so it can be used as the second addend in the equation 12 + 1 = 13.

1. Chad (intern): When Erin was at 57, what did she spin?

Both examples utilize the word “spin” but each has a different purpose in directing students in game play.

After comparing the use of the words “spin” and “chart” I was puzzled by the infrequent use of the word “chart.” I wondered if this infrequent use demonstrated that interns were not guiding students in the *where* to put the number (e.g. location on the chart), but instead were providing direction about *what* students should write. Might the focus have been on the number itself and not on the placement? For example:

1. Beth (intern): Ashton, where does 99 go in our chart?

1. Chad (intern): Three. So on this number chart where are you gonna add a three to?

1. Tara (intern): ten. Put it on our chart. What’s the number that would go on our chart?

This focus on *what* rather than *where* could explain interns’ the less frequent use of the word “chart” in their initial elicitations.

Where as Beth, Chad and Tara, in the previous example, give specific direction about *what* is to be written by students, Colin uses a more open initial elicitation when he asks:

1. Colin (intern): Okay, what do we write?

Colin is specifying neither *what* the student should write nor *where* it should be written on the game board. Here a larger portion of the intellectual work falls on the students in this group to determine what number needs to be written on the game board, what equation belongs on the equation table, and what number should be placed and where it should be placed on the Hundreds Chart. It also means that the students are responsible for knowing and following game play norms, which gives the students ownership of the game play and the mathematics they enact. Further, the simple use of the word "we," in "what do we write," reinforces the group, rather than teacher, again conveying ownership of the work of doing the mathematics and playing the game. It might be interesting to investigate the use of language to "personalize" the work in future analysis of eliciting and responding to student thinking practice.

Summary

In this chapter, I have described the ways in which interns use both task-specific language and mathematics-specific language in their initial elicitations of student thinking. Although both types of language were used by interns, the interns in this study used language related to game play (e.g., spin, write and chart) more frequently than they used language related to mathematics (e.g., adding, sum, addends and equation). This tendency suggests that although this group of interns is aware of the mathematical language, they are more focused on directing students' oral and written contributions in order to enable successful game play. This focus on the task, versus the content of the lesson, is not uncommon in beginning teacher practice (Feiman-Nemser & Buchmann, 1986). Beginning teachers are often preoccupied with carrying out a successful task, thinking the purpose is to allow student to be engage or to have fun. Unfortunately this focus often results in the underdevelopment of the content of a lesson to the detriment of the learning goals. For example, in the case of this dissertation, the task language seemed often to overshadow the mathematical language that is central to the lesson's learning goals.

The Necessary Evolution of Initial Elicitations Over the Course of the Week

It is very common for teachers to model procedures, including turn taking, when presenting or introducing a new concept or activity during mathematics teaching. The intern teachers in this study are no different. On Day 11 interns introduce the Pathways to 100 game to their students. They model the work of spinning the spinner, writing the equation and marking the sum on the game board. For example, on the first day of the Pathways game Tara narrates the work of spinning a 10 and writing the equation 1 + 10 = 11 in her initial elicitation:

1. Tara (intern): I spun a ten, so thinking about what I know about the hundreds chart, I'm going to add ten to one. And I know that it goes down, so one plus ten is eleven. And so I write that into our hundreds chart. Then what I do is I'm also gonna write this equation. So I started with the number one and I spun ten. So I added one to ten. And that equals? Can we all say it together?

In this example, Tara carefully narrates each portion of the work as she models what to do. This modeling and careful narration makes sense since it is the first day students are playing this game. But what happens on the third or the fourth or fifth day of playing this game? At what point do Tara and other interns "let go" of controlling the game through narration and allow students to take over the cognitively demanding work of recognizing the number on the spinner and using it to write an equation? By Day 13, Tara has loosened the reins of control a bit with her initial elicitation:

1. Tara (intern): It's one. Okay, what number are we at right now? And write it in

the placement.

Tara is still naming the spin, one, but instead of narrating or telling students what the starting number is, she elicits this information asking, “What number are we at right now?” She then goes back to her ways of narrating and directs the student to “write it in the placement [on the Hundreds Chart]” at the end of the elicitation. So, in this example, Tara has demonstrated a transfer of some of the intellectual work to the students in her group, but she is still bearing the burden of quite a bit of the intellectual demand. We might hope that as she teaches on Days 14 and 15, she will relinquish further control and put the majority, if not all, of the intellectual demand on her students.

The very first initial elicitation that Debbie gives on Day 11 is quite similar to the fully narrated turn that we saw from Tara:

1. Debbie (intern): Ten. So for—the first thing I’ll do is I’ll write my equation, okay? So I started at one, so I always—this last one I write first. One plus—now what did I—what did I spin?

Again, we see that she first names the spin, ten, and then describes the process of writing the equation beginning with one because she “started at one.” After naming the starting number, Debbie elicits from her students the spin, which she had stated at the very beginning of the initial elicitation. In asking for the spin, she is supporting students in connecting what she is recording in the equation, the spin of ten, with the written 10 in the equation $10 + 1 = 11$. For this initial elicitation, Debbie is taking on all of the intellectual work. She is providing all of the steps and all of the answers and doing the work of spinning, writing and adding the numbers. But on Day 15, at the end of the week, notice how her initial elicitations have changed in these two examples:

1. Debbie (intern): What's the equation? What is the whole thing?

1. Debbie (intern): Ooh, how many more do we need?

In the first example, Debbie only provides information that the student needs to write the equation. She does not name the spin, or name the starting point, nor does she indicate that the student should add or plus numbers. She simply elicits for the equation to be written, "the whole thing." In the second example, Debbie does not elicit her students' thinking about the equation at all. In fact, she is directing her students' attention to the pathway on the game board and asking how many more spins are needed to reach the game's finish at 100 on the chart. So not only are the students responsible for all of the intellectual work of writing the sentence, but they are additionally being asked about the distance on the pathway to get to 100, which increases the intellectual demand of the work even further.

As the week of teaching with the Pathways game progresses, many other interns, like Debbie, "let go" of the control of the game; their initial elicitations include less and less narration and modeling. But there are some interns, like Kathleen, who are still narrating the majority or all of the task on Day 15:

1. Kathleen (intern): So we're on number five. I'm gonna let Camaya write down the problem. So we just went from 97 to 98. Nate spun a one. So show me that number model, Camaya.

In this example, Kathleen is still naming the starting point, five, and naming the spin, and even narrating the move on the Hundreds chart from 97 to 98. She has taken away all of the intellectual work for this turn and left her student, Camaya with the work of coming up with an equation she, Kathleen, has already given. This narration makes it hard for Kathleen to know what her students are capable of, since she is actually the one doing all of the intellectual work.

Instead, we would hope to see more of what was in Debbie's example, where the intern narrates less and "let's go" more.

Most interns' initial eliciting and responding to student thinking practice on Day 15 was not all narration or all "letting go." Most interns' practice looked more like a combination of the two, or somewhere in between narrating one part of the equation but eliciting another part as we saw from Tara on Day 13. Mindy's Day 15 teaching episode demonstrates this pattern. It consisted of five initial elicitations:

1. Mindy (intern): Why don't you write right there our equation? What do you think you should write? What are you thinking you should write?

1. Mindy (intern): Twenty, okay. Where are you gonna put that? And what number are you gonna write? *[Pause]* okay. Fifty-five plus twenty—

1. Mindy (intern): Sophia, write your number in. okay. You can put it in the middle. Just make sure you circle the number. Now, Isaac, did you just say we're only gonna have to get ones to get to 100? Let's think about that, because— write us an equation. write us an equation. Let's think about that, because we have 95 more to get to a hundred. Is one the only number we could add to 95 to get to 100 that's on our spinner?

1. Mindy (intern): You got a three. Can you make a move of 3 from 95?

1. Mindy (intern): Okay. I want you to fill in. Circle it. Well, Isaac, yes. Sometimes you guys are getting ahead of yourselves. Okay, write 98 PLUS— it would be 98 and—

As evident from these examples, Mindy's initial elicitations on Day 15 are quite varied. Some include a large amount of narration, such as the second examples where she names the spin and then gives the equation saying, “fifty-five plus twenty.” Other initial elicitations, such as example four, name the spin, 3, but then elicit for the student’s understanding of the distance to 100 and if there are enough spaces to move three. And still other initial elicitations, like the first and third examples, direct students to “write” the equation. All five of these initial elicitations show varying degrees of control and “letting go” of the intellectual work. While we might hope to see more “letting go” or more consistency across one day’s initial elicitations, these examples reveal that Mindy, and her fellow interns, are still learning to deliver initial elicitations. They are still beginners, and like many beginners, their practice is irregular and inconsistent. Recognizing this pattern of inconsistency in early eliciting and responding to student thinking practice allows teacher educators to better support and focus interns’ practice. Teacher educators should guide toward “letting go” by the end of the week or the unit of instruction, but also acknowledge the interns abilities and skill at modeling and narrating which is a necessary part of teaching the first day or two of new content or a new task.

Chapter 5

FINDINGS PART 2 – THIRD TURN

Introduction

I begin this chapter by describing the four broad categories I created to describe interns' third turn of talk where they were responding to student contributions. I give a big picture of the codes for interns' third turn of talk and then turn to specific descriptions and examples of each of the codes I developed. Next, I provide a Chi Square analysis for interns' third turn of talk and the codes I applied. To conclude the chapter I give some interpretation about the significance of this analysis as a lead into the sixth and final chapter of this dissertation, the discussion.

Focusing on the Third Turn of Talk

In looking across 79 episodes of intern teaching, I examined 442 instances of the first three turns of talk. I noticed the multiple ways in which interns respond to students' contributions. Specifically, I look at the third turn of talk where the intern was responding directly to the student. These third turns of talk are best described as fitting into one of four broad categories: (1) elicitations, (2) leading prompts, (3) re-voicing and repeating student contributions, and (4) no follow-up response. I developed these categories by first distilling each episode into the first three turns of talk. I then noticed how the third turns of talk were always made by interns, who regularly requested something on the part of the students in the discussion group. I realized that these kinds of requests were actually elicitations. Some of these elicitations were true questions that were asked by the intern to gain information about the thinking of the student. But some of the requests were actually leading questions that guided students toward a particular mathematical procedure or answer, rather than uncovering their thinking. In a small number of cases, the intern did not attempt a follow-up elicitation and in these cases, where there was no intern contribution after a student's second turn of talk, the third turn was coded as *none* for no follow-up response.

It is important to note that when applying these codes the categories were not mutually exclusive. I chose to code each turn of talk separately, but in many cases an intern's turn included several utterances. Take for example this third turn elicitation given by Valerie:

3. Valerie (intern): Okay, write a number model. Evan, is he right to put the 99 there? So if we go from 89 to 99, is the number in the ones place or the number in the tens place change?

This third turn was given three codes: (1) focusing on place value, (2) considering others' thinking or work, and (3) managing. Valerie's use of the phrase "tens place" was coded as focusing on place value. Her asking Evan "is he right" was coded as considering other's thinking or work since Valerie is asking Evan if another student's work, indicated by the pronoun "he" is right. Finally, the prompt, "if we go from 89 to 99" is coded as guiding because Valerie is guiding Evan through a particular move on the game board, rather than eliciting information about this move from Evan.

In order to best understand intern's third turn responses to student answers, I first needed to classify the kinds of answers that students were providing. I looked at the answers in order to see the connection between these second turn student contributions and intern's third turn responses. Although the third turn codes are not mutually exclusive, the codes applied to student answers are. This means that for the 442 units of analysis I have coded each student second turn contribution as either correct, incorrect or non-response. Take the following example:

1. Henry (intern): Okay, where do we go? What's our equation? Oh, I wonder where

we're gonna land? What do you think? What did we just roll, Xavier?

2. Xavier: He rolled 30.

3. Henry (intern): Yeah, so where do you think we're gonna land?

In this example, Xavier's answer to Henry's question of " What did we just roll, Xavier?" was coded as correct. No other codes were applied to Xavier's contribution, nor were any second turn contributions from students coded in more than one of the three student answer codes.

Elicitations

As defined earlier in this section, an elicitation is a request for something which is used to gain access to information about an individual's thinking. There are different elicitations that interns made during these teaching episodes. These different elicitations constitute different kinds of requests, in terms of what the student has to do. To better understand and describe the elicitations that interns are making early on in their learning of this practice, I have divided the third turn elicitations into different types of requests for different types of work. My analysis of the elicitations reveals that they can be categorized into one of five types: (1) focusing on place value, (2) probing for student thinking or meaning, (3) linking or applying to another representation, (4) considering other's thinking or work, and (5) making a prediction.   Table 5-1 gives a general overview of these codes. In the following sections I describe each category and provide examples.

Table 5-1: Eliciting Codes with Descriptions and Anchor Examples

Eliciting Code	Description	Example
Focus on place value	Intern's elicitation focuses on key elements of the task (e.g. place value)	•Why is there an eight in all of these? 68, 78, 88. Why is there an eight? •He said we had nine ten spins. How many one spins did we have?
Explain meaning	Intern's elicitation asks student to explain their thinking or what they did	•How do you know it's 80? •Seventy-nine. How did you know that? How'd you know it was a nine? •Why is that? Why do you think? •And Felicia how did you know that is where the 12 went? •How do you get from 33 to 34? •Can you show me how you got there?
Link/apply	Intern's elicitation connects mathematical representations. Specific mention of the chart or hundreds chart	•So where would this go on the chart? •Ashton, where's 24 going? •Thirty. Did we—and where did we land?
Consider other's thinking or method	Intern's elicitation asks student to consider, explain, or connect to another's answer, thinking or method of solution	•Okay, Evan, I want you to notice that Boaz is doing that. What do you notice about these numbers? •Twenty-one, 34, 44, 54? •He added 1 to 33, where are we gonna put our answer? •Does anybody think differently? •Okay, Isaak, so Alex wrote 21 plus ten equals 31. Does that look right to you?
Agreement*	Intern asks student if s/he agrees or disagrees	•22, do you agree Anthony? •71 plus 1 equals 80. Do we—do we agree with that, Modessa?
Predict	Intern's elicitation asks student to make a prediction, usually about the answer, the next spin or how far to get to 100	•So, what is—what does Makayla need to spin to get to 100? •How many more do we need to get to 100? •All right. Now you guys are getting pretty far, but how many more do you—how many do we need? •What spins do we need to get to 100? How many?

*Agreement is a special case of the code "Consider other's thinking or method"

Focusing on place value. Intern elicitations were coded as focusing on place value if they exhibited one or more of these three moves: (1) asked about ten or one, (2) drew a student's attention to a series of numbers that have similarities in terms of the tens or ones place, or (3) directly used the words "place" to refer to the ones place or tens place of a number. For example, Tara elicits student thinking by using a move that asks about spins of 10:

1. Tara (intern): Okay. So, we spun three tens, right? So we jumped from 70 to 80, one jump of ten, and then we jumped from 80 to 90, and then we

jumped to 100 and that's ten. We jumped ten. We jumped ten. And we jumped ten. [*pointing to the hundreds chart*] And then now how many tens did we jump in total?

2. Nayana: Thirty.

3. Tara (intern): And what if we did the same thing up here? So from 12 to 13 we jump one. From 13 to 14—from 12 we jumped one. How many did we jump total?

By drawing students' attention to the successive jumps of 10, Tara is supporting student thinking and learning about adding tens. In particular, she is connecting the students' knowledge of the spins in the game to the tens column on the hundreds chart, see Figure 5-1 below.

1	2	3	4	5	6	7	8	9	10
11	12	13	14	15	16	17	18	19	20
21	22	23	24	25	26	27	28	29	30
31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	49	50
51	52	53	54	55	56	57	58	59	60
61	62	63	64	65	66	67	68	69	70
71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90
91	92	93	94	95	96	97	98	99	100

Figure 5-1: Focusing Students' Attention on the Columns of the Hundreds Chart

Similarly, Valerie elicits students' thinking about place value by actually using the phrases "ones place" and "tens place" in her third turn elicitation:

1. Valerie (intern): Okay, we got a one. Evan, where are we going to go? We're at 88 and we spun a one. Point to the space where we're gonna go. Okay, put that in. Is he right, Delaun? He put the 89 here. Is that

right? How do you know?

Delaum: Because 88, 89.

Valerie (intern): And which number are you changing? The number in the ones place or the number in the tens place?

With this move, Valerie names the places in the number asking "which number" or "place" is changing and in doing so she draws students' attention to the change from an 8 to a 9 in the ones place. Likewise, Chad uses the third move, giving a series of numbers that have similarities in the ones place:

1. Chad (intern): I got something I want to talk about. Look. He said 78 plus 10. Let's look right here. What—we're at 78 and we went to 88. Okay. Why is there an eight in all three of these? Are there?
2. Natasha: [student is silent and does not respond to Chad's question]
3. Chad (intern): Why is there an eight in all of these? 68, 78, 88. Why is there an eight?

Chad's third turn elicitation focuses students on place value. In listing the numbers 68, 78, 88, in fact, he probes the ones place specifically by mentioning the "eight" that occurs in the ones place of all of these numbers.

Probing for student thinking or meaning. When interns probed for student thinking or meaning they did so by asking an individual student to explain his or her thinking or what he or she did to arrive at a given answer. For example, Brooke responds to Anthony's correct answer of 80, by asking how he knows the answer to the equation 79 + 1 = 80:

1. Brooke (intern): All right. What's 79 plus—
2. Anthony: It's 80.

3. Brooke (intern): How do you know it's 80?

Anthony is correct, 80 is the sum. But instead of accepting this correct answer and moving on, Brooke further elicits by asking, "How do you know it's 80?" In asking this question she is uncovering the student's thinking around this particular equation. Brooke is giving Anthony an opportunity to share what he knows. Interns also used probing for student thinking or meaning when students did not produce a correct answer. In the following example Haley uses a probe in the third turn to ask a student what he did, mathematically, as a way to reframe her previous elicitation from the first turn:

1. Haley (intern): Devon, you're gonna write our equation. So we started at 33 and I want you to demonstrate how we got it.
2. Devon: I don't know.
3. Haley (intern): How do you get from 33 to 34?

Here, Haley breaks down the work of writing out the equation 33 + 1 = 34 by asking Devon, "How did you get from 33 to 34?" Rather than telling Devon that a one was spun, she is eliciting this information from him, so that he can explain what has happened during game play and then write the equation to match this game play.

Another way interns probed for student thinking or meaning was to extend a student's thinking and probe about the procedure that was used to arrive at the correct answer.

1. Keith (intern): Okay! Mulugetta got us a 30, so Myree, we're at 2 and then we added 30, now where are we gonna go on the chart?
2. Myree: We are gonna go way down here. [student points to the place where 32 goes on the hundreds chart]
3. Keith (intern): Can you show me how you got there?

Here, Myree correctly identifies the place on the hundreds chart where 32 goes, and Keith elicits Myree's method, asking him to describe or "show" how he got to 32. By asking this question, "Can you show me how you got there?" Keith has done two things: (1) he has opened up Myree's thinking for the whole group to examine, and (2) he can check to see if Myree got this answer in a mathematically sound way or if he has just guessed the right answer.

Linking or applying one mathematical representation to another. During the game, Pathways to 100, interns and students are moving between multiple mathematical representations. They move from the spinner, which often displays a 10 or a 1, to a 10 by 10 empty hundreds chart game board. There is also a portion of the game board where students write a number model in the form of an addition equation. In addition there are filled in hundreds charts in the classrooms on display for intern and student use. So, when coding for linking and applying, I noted any instance that connected two or more mathematical representations (spinner, game board chart, game board equation, or class chart). I also coded any mention of the word "chart," "grid" or "hundreds chart" as linking or applying one mathematical representation to another. The following example is coded as linking and applying because David mentions the "hundreds chart" in his third turn elicitation:

3. David (intern): Sixty-five, right. Aaron, can you mark us on the hundreds chart where we're at now?

In a similar example, Debbie references the "chart" in her third turn elicitation:

3. Debbie (intern): Okay, where are you gonna write your number on the chart?

On multiple occasions, interns referenced the chart using language other than "hundreds chart" or "chart." One case of this occurs when Henry asks his student where they will "land" on the hundreds chart.

1. Henry (intern): Okay, where do we go? What's our equation? Oh, I wonder where we're gonna land? What do you think? What did we just roll, Xavier?
2. Xavier: He rolled 30.
3. Henry (intern): Yeah, so where do you think we're gonna land?

From the context provided by the transcribed dialogue, and the video record, I was able to discern that Henry is using the term "land" to mean placement on the hundreds chart game board. What he is effectively asking is, "Where do you think we're gonna land [on the hundreds chart]?" Kathleen uses a similar verbal cue to indicate the hundreds chart in her third turn elicitation:

1. Kathleen (intern): So what did we spin?
2. Camaya: Oh, 53 plus 1 equals 54.
3. Kathleen (intern): 54, where's that 54 gonna go?

When Kathleen asks, "Where's that 54 gonna go?" she is, in fact, asking "Where's that 54 gonna go [on the hundreds chart]?"

On some occasions, interns did not mention the hundreds chart specifically, but pointed to it as a way of linking one representation to another. For example:

1. Debbie (intern): Ten. Okay, ready for the number sentence. We're at thirteen, and we're adding ten. How do we write that in the number sentence?
2. Elijah: Wait, thirteen plus ten plus— [student writes the equation as he says it aloud]
3. Debbie (intern): Okay, how did you know the total for here [*pointing to the hundreds chart*]?

Debbie connects what Elijah writes in the equation section of the game board to the hundreds chart on the game board by pointing to the place where 23 belongs.

In coding linking or applying one mathematical representation to another, I noticed a distinct pattern of elicitation where the intern first asks for the equation that represents the location on the game board plus the spin, and then asks for the placement of that sum on the hundreds chart. In fact, my analysis revealed that in more than 13% (58/442) of cases the intern's initial elicitation was about the equation and the follow-up elicitation was about the hundreds chart.

Considering others' thinking or work. The work of considering another person's thinking within the context of this study encompasses the kinds of questions interns pose to students that require the student to consider the thinking or work of another individual. This elicitation could ask the student to consider another person's thinking as explained aloud during discussion. Alternately, it could ask the student to consider the work or answer that is written or verbally communicated by another person. Or, it could request that the student repeat or explain another person's method of solution or thinking in his or her own words. Elicitations that require the student to consider another's thinking or work are more complex than simply explaining one's own thinking. In fact, it is not only harder to do, but harder to elicit from students. The work on the part of the teacher that is needed to elicit one student's thinking in consideration of another student's thinking is complex. It requires the teacher to understand the first student's thinking and to purposefully connect the second student's thinking to what has been contributed. Additionally, it requires the teacher to select student thinking that is both worth connecting to while still moving the discussion forward toward an intended mathematical point. By "worth connecting to" I mean that the contribution offered by the first student is important for understanding or doing the mathematical task at hand, such that other students can learn from or advance their thinking in light of it.

When asking students to consider another person's thinking, interns' elicitations fell into one of three categories: (1) re-voice or repeat what was said, (2) act on what was said by either writing about it or making a move on the hundreds chart, or (3) agree or disagree with what was said. For example, in the following sequence Kit uses a third turn elicitation to engage one student's thinking using another's verbal contribution:

1. Kit (intern): So, do you see—do you see any patterns?
2. Kimberly: It almost all—these three all had six, and then we had seven, eight, nine, nine, nine.
3. Kit (intern): Okay. So what does it tell you? What did—what did Kimberly just say about the patterns that she showed?

In this example, Kit uses the elicitation, "What did Kimberly just say about the patterns that she showed?" to get a student to re-voice or repeat what Kimberly said. This is a more sophisticated request as it requires the student to not just agree or disagree but (1) to attend to another person's thinking, and (2) to explain this other's thinking in her or his own words. This kind of elicitation serves more purposes than a simple elicitation for a follow-up action or an agreement. It requires an individual student to put aside his or her own thinking and to describe the thinking of someone else. When used strategically, a teacher can draw attention to mathematically central ideas and thinking. In this case, Kendra draws attention to Kimberly's thinking by having another student re-voice what Kimberly said. She does what I refer to as "opening up" the thinking of one student for other to consider, evaluate and learn from. It is one way that groups share and build knowledge collectively. This kind of knowledge building is a shift from the historically documented dynamic between knowledge, teacher and student, where the teacher is the sole possessor of knowledge and therefore distributes such knowledge to the student by telling. In this example, there is a shift of authority that happens in Kendra's move to "open up" Kimberly's thinking to the group. When Kendra, the teacher, places the intellectual authority, or knowledge with Kimberly, Kimberly, the student, is seen as the knowledge bearer, rather than the teacher.

In another instance, Allison has a student consider another student's written work:

3. Alison (intern): Okay, we need to look at Eddie's equation, because where are we gonna put our number?

Allison directs the student to look at Eddie's written equation on the game board and then write the number, or sum, on the hundreds chart. In this way student A must use what student B (Eddie) has written, consider this, and act on it by writing the sum from student B's equation in the correct place on the hundreds chart.

The third category of considering another person's thinking or work is agreement. During teaching episodes interns regularly asked students if they agreed or disagreed with a contribution made by their student peer. For example:

1. Kendra (intern): So let's write the next equation for that one and see if this makes our number pathway look a little different.
2. Amanda: [writes 10 + 34 = 44]
3. Kendra (intern): Okay, so Zach says 10 + 34 = 44. What do you think? Does that make sense?

In the third turn, Kendra asks an individual student, as identified by name, *"What do you think?"* This interaction is a very open elicitation, which requires the student to share his thinking more broadly. The intern does not specify what kind of response is desired, but rather elicits any and all thinking the student may have. Unfortunately this open elicitation is followed up with an elicitation that is more limited and only requires the student to give a "yes" or "no" response. If the intern had ended the elicitation after, "What do you think?" the student would have needed to respond with more than a "yes" or "no" answer. So the follow-up elicitation of "Does that make sense?" effectively mutes the strong elicitation of "What do you think?" I use the word "mute" to describe the effect that the follow-up "Does that make sense?" has on the stronger prior elicitation of "What do you think?" As with music, the sound or content of the question gets turned off and goes away. The elicitation of "What do you think?" goes away leaving the student to instead answer the question, "Does that make sense?" In doing so, Kendra has effectively erased or muted her earlier strong and open-ended elicitation, "What do you think?"

In the following example, Kendra uses a series of follow-up elicitations that do not mute the earlier elicitations.

1. Kendra (intern): I'm gonna have Skylar write the equation. So we spun a 10. What should our equation be?
2. Amanda: [writes the number on the chart]
3. Kendra (intern): You think it's gonna go here? What do you guys think? Does anybody think somethin' different? How did you figure out that it would go there?

In this case, Kendra is opening up the thinking of one student, "You think it's gonna go here?" to the group, "What do you guys think?" and "Does anybody think somethin' different?" The final elicitation, "How did you figure out that it would go there?" is probing further by asking the student (or students) to explain their reasoning or method for placing the number on the hundreds chart. This elicitation is quite strong. First, it confirms what the student said. Second it opens up the discussion to include all students in the group while simultaneously asking for consensus, an important discussion move **and** an important mathematical move. Finally it further probes for reasoning or method of solution to get at the underlying conceptual and procedural understanding of the students.

Making a prediction. When eliciting students to make a prediction interns most often asked their students to make predictions about the distance to get to 100 on the hundreds chart and win the game. Sometimes interns were vague when asking about the distance to 100 as in the following example:

3. Valerie (intern): How many more do we need to get to 100?

In this case, Valerie is not specific about whether students are to give the number of spins needed to get to 100 or the number of squares on the hundreds chart that are needed to land on 100. Using a predicting elicitation is tricky for some interns, as exemplified in Maggie's third turn:

3. Maggie (intern): How many more—how far are we from 100? We're at 25 right now.

In this example, Maggie stumbles with her words, stopping, restarting and changing her question from "How many more?" to "How far?" When Maggie changes the way she is asking the question, she goes from asking about spins, "How many more [spins]" to get to 100, to "How far are we from 100?" This revised elicitation asks students to find the distance to 100 because the word "far" is a word related to distance in mathematics. Maggie further focuses her students' attention on distance by indicating that they are "at 25", the starting point, and need to move "far" to get to 100. Effectively, Maggie is asking her students to predict the number of moves or squares on the hundreds chart between their current game position, 25, and 100.

While most interns' elicitation about predictions were more vague, as in the case of Valerie and Maggie, sometimes interns asked directly for the spins that could be used to reach 100. For example:

1. Brooke (intern): Okay. Let's let her write the equation first. Seventy-eight plus ten is—
2. Andy: It would be here [*pointing to 88*]
3. Brooke (intern): Now you guys are getting pretty far, but how many more do you—how many do we need? What spins do we need to get to 100?

In this example, Brook specifies "What spins" do we need to get to 100. She does not ask how many spins, nor how far is it on the hundreds chart to get to 100, but rather asks students to predict the exact spins that would be needed to travel from 88 to get to 100. Chad employs a similar move when he asks students about the single spin that will get them to 100:

1. Chad (intern): Oh. So, what is it? 98 plus 1 is what? What is this?
2. Elijah: 99.
3. Chad (intern): Okay. So, what is—what does Makayla need to roll to get to 100? Or spin?

Chad's group has made a pathway all the way to 99 and only needed one more spin to get them to 100. Chad uses this opportunity to check student understanding around the final spin. He wants to know if his students can predict if the final spin, from 99 to 100, is a one. By asking, "What does Makayla need to [spin] to get to 100?" Chad specifies that the "spin," rather than the distance or move on the game board, is the focus of the work to get to 100.

Leading Prompts

Leading prompts are third turn follow-ups where interns direct or lead students through game play and talk about the Pathways to 100 game. These kinds of prompts fall into three broad categories: (1) managing game play and student behaviors, (2) guiding students through a procedure or toward an answer, and (3) telling by giving the answer previously elicited.

Managing. Managing signals the work interns do to explain or direct students in the rules or procedures of game play: for example, spinning the spinner, writing an equation for the spin or placing a number on the hundreds chart. In this first example Allison directs the student to spin the spinner:

1. Allison (intern): Okay, what's our equation? We ended on 45. Oh, you have the answer.
2. Student: [writes on the hundreds chart]
3. Allison (intern): All right, give me another spin, Olivia.

In this second example Todd directs the student to write the equation for the spin of 10:

1. Todd (intern): Oh, so write up your number. What's the next number?
2. Student: [writes on the hundreds chart]
3. Todd (intern): Okay. Now write the equation out, please.

In this case, Todd has directed the student to "write the equation out" on the game board. His third turn is stated as a command or direction, rather than as a question. This is different from Pricilla's elicitation in the following example:

1. Pricilla (intern): Ten, all right. Alex, go ahead and write the equation so—
2. Alex: [writes the equation]
3. Pricilla (intern): Okay, Isaak, so Alex wrote 21 + 10 = 31. Does that look right to you? Is that right? Twenty-one plus ten equals thirty-one? Okay. Where would you write it on the chart? Where would you write 31

on the chart?

In some cases, managing is intern and student talk around behavior expectations and group work. Specifically, interns used the S.T.A.R. model (**S**it up, **Tr**ack the speaker, **A**sk and answer questions, **R**espect others) to support students' engagement with the mathematics and with one another. In the following example, Allison's third turn elicitation is focused on managing Ty's behavior when he uses his hand to push another student's hand out of the way:

1. Allison (intern): Okay, Eddie, can you wait your turn. I know you know the answer, and I know you wanna write it down, but can you just wait until he's done? Thank you. How did we know we could just jump down there? How did we know that?
2. Ty: [Hits Eddie with the back of his hand]
3. Allison (intern): Oh, we don't hit, Ty. We don't hit. Okay, let's go over—what is S.T.A.R. behavior? Can someone give me the S? What's the T?

Allison's initial elicitation of, "How did we know we could just jump down there? How did we know that?" does not get taken up by the students because of the behavior that arises and requires her attention. Instead of using a follow-up elicitation about the mathematics, Allison responds with a well-timed managing move to reorient her student to the behavior norms for their work eliciting their knowledge of the "S" and "T" from S.T.A.R. behavior. She provides Ty with an alternative to hitting, eliciting that students need to instead **Tr**ack the speaker and **A**sk and answer questions during this instruction.

Guiding. The most common component of interns' third turn response to student contributions is a leading prompt that guides a student or group of students through a specific mathematical procedure or toward an intended answer. In all cases that were coded, the mathematical procedure or intended answer was related to the lesson task, which was a mathematical game that focused on place value concepts. If the leading prompts were unrelated to a mathematical procedure, or given as a direction or statement, rather than a question, the leading prompt was coded as management of student work or response. For example the following third turn response from Allison is coded as management.

3. Allison (intern): All right, give me another spin, Olivia

Here Allison is directing the student to spin the spinner as part of game play. There is neither mathematical work being done, nor is Allison asking a question of her students. Alternatively, a guided response is one where the intern is leading the student toward a particular answer using a question as the vehicle. Often, this kind of leading prompt is a question that has a yes or no answer and therefore does not uncover a student's thinking. Further, a guiding prompt in the form of a question often gives away more information that it elicits. For example when Chad asks,

3. Chad (intern): Are you sure 60's there?

He is actually giving away some information about whether he (Chad) believes 60 is correctly placed on the hundreds chart. In this way, his question does not serve to elicit what the student thinks about the placement of the number 60, but rather serves to inform the student that her placement of the 60 is incorrect and needs to be reconsidered and revised. Had Chad responded with a question that was more general and open, for example, "How do you know that 60 goes there?" or a question that specifically probes the student's reasoning around the placement of the 60, for example: "Why did you place the 60 there on the chart?" the student would have been expected, and felt compelled to share her thinking by explaining her method for placing the number 60 on the chart. Instead, Chad's question is simply answered by the student with a, "No." Therefore, Chad does not learn about the student's thinking or method of placing the 60 on the chart. This is also a missed opportunity for other students in the group to learn from this misplacement.

Telling. For the work of this dissertation I have decided to classify those instances where an intern asks and then answers the question they have posed as telling. Telling is different from filling in as defined by Boerst et al. (2015) in their research of pre-service elementary teachers' performance on baseline and mid-term mathematics assessments, and described as, "stating what a student is thinking instead of asking the student about her/his thinking." In the case of telling, the intern has asked the question about what the student was thinking, but has not persevered in probing further or using time to wait for the student's response. Instead, the intern gives or tells the answer rather than allowing the student to answer. For example:

1. David (intern): Fifty-five plus ten, what is it?
2. Jenna: [no answer from student]
3. David (intern): Sixty-five, right?

In this case, David does not give the student a chance to answer his questions "Fifty-five plus ten, what is it?" but instead follows up by answering the question, telling the student that fifty-five plus ten is sixty-five. In another case, Veronica uses her third turn to tell her students, "We need one more spin, one more ten," and then elicits the very same information she has just given:

3. Veronica (intern): We need one more spin, one more ten. How many more do we need—numbers do we need to get to a hundred—90 plus what is 100?

She is asking what number is needed to, "Get to a hundred" and then rephrases her question with additional scaffolding saying, "90 plus what is 100?" Veronica is effectively asking her students to repeat what she has already told them. In attempting to connect 90 + ? = 100 to the spin of 10 she has scaffolded so much as to take away the mathematical rigor of the work for her students.

Re-voicing and Repeating Student Contributions

One move that interns used for the third turn was a re-voicing move. This move either repeated or rephrased a contribution the student had made during the second turn. For example, in the third turn, Chad re-voices the "one" that Sayo contributes in the second turn:

1. Chad (intern):	When Erin was at 57, what did she spin?
2. Sayo:	I got a one.
3. Chad (intern):	A one.

In this case, Sayo has answered correctly. Erin did spin a one and Chad chose to repeat this correct information, the spin of one. In another set of turns on the same day (Day 15) Chad re-voices Erin's incorrect contribution:

1. Chad (intern):	Seventy? How'd you know it was 70?
2. Erin:	Sixty plus seven?
3. Chad (intern):	You're sayin' 60 plus 7 is 70?

In doing so, he is drawing attention to the student's contribution, 60 + 7 = 70. From the video of this interaction it was noted that Erin's second turn is spoken as a question, the pitch of her voice rises at the end of her contribution signaling that she is unsure if she is correct. Chad repeats what she has said, connecting it back to his initial elicitation about 70, and in doing so opens up a group discussion around the equation 60 + 7 = 70.

Sometimes, a repeating or re-voicing move was used by the intern reading aloud what a student had written, rather than spoken. One example of this occurs when an intern speaks aloud the number a student has written on the hundreds chart portion of the game board in Figure 5-2.

3. Kit (intern): Four. What's the, what's the number? How did you get four?

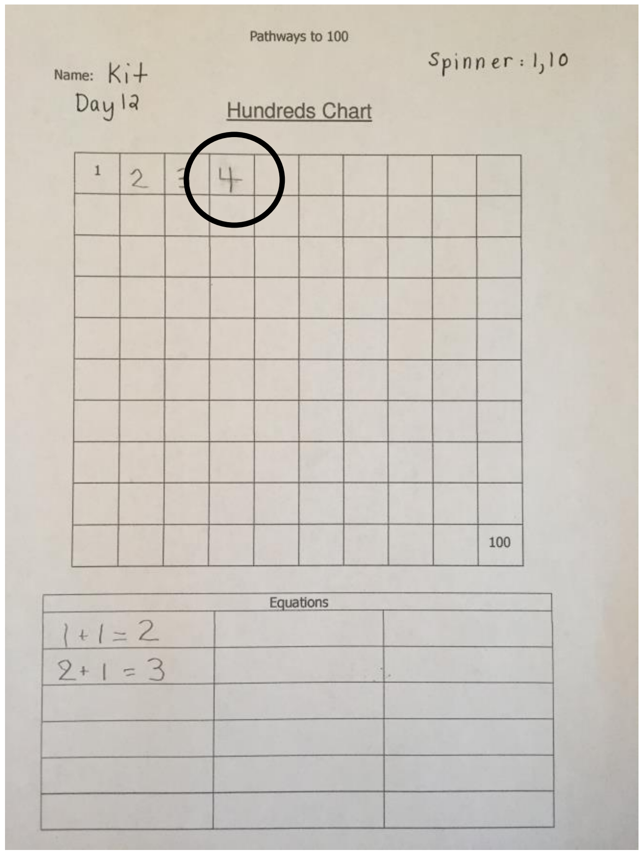


Figure 5-2: Hundreds Chart Game Board Kit's Group is Using for Game Play on Day 12

Kit's student writes the number 4 on the Hundreds Chart portion of the game board, but has not filled out the equations section of the board. Kit re-voices the number she sees written on the Hundreds Chart, four, and follows up with a set of eliciting questions. Kit's elicitations are tied directly to the Hundreds Chart game board and what the student has written. In another similar example of this pattern, an intern speaks aloud the number model a student has written on the equations portion of the game board in Figure 5-3.

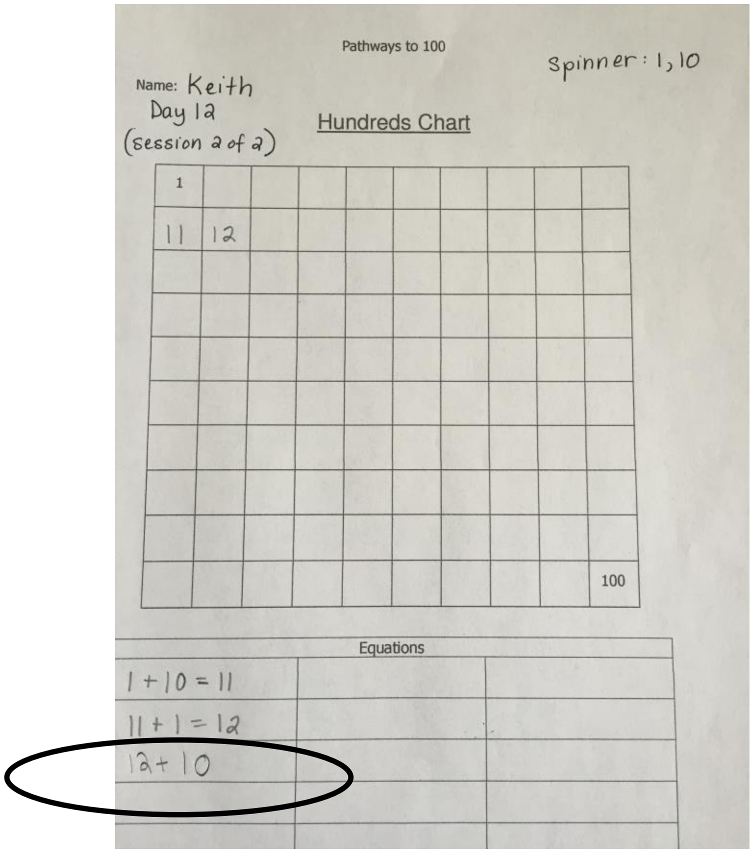


Figure 5-3: Hundreds Chart Game Board Keith's Group is Using for Game Play on Day 12

After the student writes the first part of the number model, 12 + 10, the intern reads this partial equation aloud affirming that what Bradley has written is correct, and then further elicits the student for the sum, the answer, to the equation.

3. Keith (intern): Bradley, you wrote 12 + 10, and what's the rest of your number model?

In reading Bradley's partial number model aloud further probing his thinking with a follow-up eliciting question, Keith is connecting his question to the number model on the game board.

No Follow-up Response

In some cases the intern did not follow-up after the student's response to the initial elicitation. In these cases, the intern offered neither a leading prompt, a re-voicing move nor a follow-up elicitation for the third turn of talk. Instead, this set of turns ended, and then game play resumed with a new spin followed by the intern using an initial prompt or elicitation related to this new spin. For example, Brooke offers an initial elicitation prompting the students to write the equation in the game board.

1.	Brooke (intern):	All right. Let's write our equation. It's your turn to write.
2.	Andy:	And then she spins, and then I spin, and then she spins one more. This one should be easy.
3.	Barbara	[spins the spinner]

As one student, Barbara, writes the number and equation, Andy makes a prediction describing how the next set of turns will go. He presents an opportunity for Brooke to elicit his thinking about the next spins, but Brooke remains silent. After Barbara finishes, she spins the spinner. In spinning the spinner, Barbara begins the next turn, and since Brooke does not stop her, or interject with a question or prompt, there is not follow-up elicitation. Similarly, Valerie's initial elicitation prompts the student to write the equation.

1.	Valerie (intern):	Cuz it's a bigger number. All right, Evan, he rolled a ten. If we add ten to one, why don't you go ahead and write-write what the sum would be.
2.	Evan:	[Evan writes the equation]
3.	Valerie (intern):	Good. Good, Evan. [Pause] All right, we're off to a good start. Evan, how about you give this a spin? Thanks, guys. And you—try it one more time. Try going around like that.

Once Evan has written the equation, Valerie evaluates his work, saying "Good. Good, Evan." She pauses for four seconds and then asks Evan to spin the spinner for the next turn, instead of using a follow-up move.

Chi-Square Test of Independence

A chi-square test of independence was performed to examine the relation between the third turn response interns gave to correct, incorrect, and non-response answers from students. The relation between these variables was significant for five of the eleven third turn categories tested. Significance was found for *link/apply to representations*, χ^2 (2, n = 88) = 10.091, P<0.05. Interns were more likely to use the elicitation: link/apply to representation elicitations in response to students' correct answer to the initial elicitation, than when students' answers were incorrect or non-responses. Similarly, significance was found for *guide*, χ^2 (2, n = 296) = 12.635, P<0.01. Interns were more likely to use the leading prompt: guide in response to students' correct answer to the initial elicitation, than when students' answers were incorrect or non-responses. Significance was found for *tell*, χ^2 (2, n = 16) = 12.153, P<0.01. Interns were more likely to use the leading prompt: tell in response to students' non-responsive answer to the initial elicitation, than when students' answers were correct or incorrect. Additionally, significance was found for *re-voice*, χ^2 (2, n = 75) = 8.851, P<0.05. Interns were more likely to re-voice a students' answer if it was correct than if it was incorrect or a non-response. Finally, significance was found for *no follow-up response*, χ^2 (2, n = 25) = 6.086, P<0.05. Interns were more likely to not follow-up (meaning the instructional sequence ended after the second turn) when students responded with correct answers, than with incorrect or non-responses from students. These results appear in Tables 5-2, 5-3, and 5-5 and are described in greater detail in the following sections.

Chi Square for 3rd Turn Elicitations. Table 5-2 presents the 3rd turn follow-up elicitations from interns in relation to student answers. Over all, there were more instances of student correct answers to interns' initial elicitations (n = 296) than either student incorrect answers (n = 72) or student non-response (n = 59). For example, there were 39 independent instances of intern 3rd turn follow up elicitations coded as "place value." See Figure 5-4 below.

	Intern 3rd Turn Elicitations	
	Place Value	
Student 2nd Turn Answer:	n	%
Correct (n = 296)	39	13.2

Figure 5-4: Excerpt from Chi Square Table 5-2

The number of 3rd turn follow-up elicitations categorized as "place value" is also represented as 13.2% of total correct student answers (39/296 = 13.2). This means that 13.2% of all correct student answers were follow-up by interns with a place value elicitation.

In the category of intern third turn elicitations, linking and applying to representations was found to be statistically significant. In fact, 72 of correct students responses were followed-up with an elicitation that link/apply to a mathematical representation, compared to 3 of incorrect student responses, and 13 of non-response from the student.

Table 5-2: Chi Square for 3rd Turn Elicitations

	Intern 3rd Turn Elicitations											
	Place Value		Probe Thinking or Meaning		Link/ Apply to Representations		Others' Thinking or Work		Agree		Predict	
Student 2nd Turn Answer:	n	%	n	%	n	%	n	%	n	%	n	%
Correct (n = 296)	39	13.2	51	17.2	72	24.3	24	8.1	20	6.8	12	4.1
Incorrect (n = 72)	4	5.6	8	11.1	3	4.2	5	6.9	1	1.4	1	1.4
Non-Response (n = 59)	9	15.3	12	20.3	13	22.0	4	6.8	1	1.7	0	0
χ2:												
F	2.632		1.277		10.091		0.126		4.502		3.248	
df+	2		2		2		2		2		2	
P	0.2683		0.5281		0.0064*		0.9389		0.1053		0.1972	

df+, degree of freedom
*P<0.05
**P<0.01

Although interns used a linking and applying to representations elicitation to respond to all three types of student answers, more often this kind of elicitation was given in response to a student's correct (24.3 %) or non-response (22.0 %) answer. For example, Colin responds to Darian's correct answer asking about the game board, which is one of the mathematical representations being used in the game.

1. Colin (intern): Okay. So, Darian, what did we get here?

2. Darian: A one.

3. Colin (intern): One. And where are we on the board?

In another example, Beth prompts Ashton to use the chart to help him write the equation in response to his non-response to her initial elicitation:

1. Beth (intern): Okay. So write the equation.

2. Ashton: [Silent. Holds the pencil but does not write anything on the chart.]

3. Beth (intern): Can you maybe see in the chart?

Responding to an incorrect answer with an elicitation that linked one representation to another was a rare occurrence. Fewer than 5% of students' incorrect answers were met with a linking and applying to representations elicitation. In the following example, Brooke uses a linking and applying to representations elicitation. Her elicitation is in response to an incorrect answer given by her student, Hope:

1. Brooke (intern): Okay, so we're gonna use that 10, and so I'm going to start at 2 here. So then what's our answer?

2. Hope: 1 and 10.

3. Brooke (intern): Yep, those are the numbers we have on our spinner, but we're looking at the chart right now, okay? So we have our answer or we

have our equation, 2 plus 10 equals 12. Where's 12 going to go on the chart?

Hope's wrong answer seems to be more about the spinner, and spinning a 1 or a 10, than about the answer or sum for the equation for the spin. Brooke uses an eliciting prompt that references the chart, a mathematical representation, to connect what Hope has contributed about the spinner to the placement on the chart.

In summary, the larger *N* of student correct answers, compared to the other two types of student answers, is likely the reason for significance in the linking and applying to representations elicitations category. In this data set, the difference in percentages between interns' use of linking and applying elicitations after a student's correct or non-response answers were five times more likely than if a student provided an incorrect answer. It makes sense that after a student provides a correct answer, an intern would extend this answer, and the student's thinking, by asking the student to apply the answer to the game board or equation. Equally true is the fact that the work of the game has three components: (1) spinning, (2) writing the equation, and (3) placing the number on the chart. If the intern's initial elicitation has already accomplished the work of 1 and 2, then it stands to reason that the intern's response to the student will be to get 3, placing the number on the chart, completed. Further, it makes sense that when a student is struggling to produce an answer, as Ashton does in the last example, a teacher will attempt to support that student by making a connection to the physical representations of the mathematics. It is likely that this is what Beth is doing. Her choice to provide some support, by way of the lesson materials, may signal a shift in her own orientation. Rather than calling on another student, or giving Aston the correct answer, she provides support related to what she knows he is already familiar with, the hundreds chart. This example makes me wonder if there are more moments like this one in the data, where interns are engaged in a shift in orientation toward student thinking.

Chi Square for 3rd Leading Prompts. Table 5-3 presents the 3rd turn leading prompts in relation to student answers. In the category of leading prompts, both guiding and telling were found to be statistically significant.

Table 5-3: Chi Square for 3rd Leading Prompts

	Intern 3rd Turn Leading Prompts					
	Manage		Guide		Tell	
Student 2nd Turn Answer:	n	%	n	%	n	%
Correct (n = 296)	44	14.9	116	39.2	5	1.7
Incorrect (n = 72)	12	16.7	46	63.9	5	6.9
Non-Response (n = 59)	9	15.3	34	57.6	6	10.2
$\chi 2$:						
F	0.402		12.635		12.153	
df+	2		2		2	
P	0.8179		0.0018**		0.0023**	

df+, degree of freedom
*P<0.05
**P<0.01

Telling. Interestingly, telling seems to be occurring in intern response to student contributions regardless of the answers students provide. This finding surprised me. I had anticipated that interns would do more telling when student answers were incorrect or not given. I didn't understand why an intern would tell an answer if the student were already on the right track and had provided a correct answer in the previous turn of talk. I wondered if perhaps individual interns were telling more than others and this tendency was impacting the data. So I investigated the frequency with which interns were telling in their third turn elicitations. I found that less than half (12/17) of the interns in this study used telling in their follow up elicitation, see Table 5-4.

Table 5-4: Frequency of Intern Telling in Their 3rd Turn Responses to Student Answers

	Intern	n
	Allison	2
	Beth	1
	Chad	1
	David	2
	Keith	1
	Maggie	1
	Sandra	3
	Stacy	1
	Tara	1
	Todd	1
	Veronica	1
	Zoe	1
Total	12	16

Further, no intern used telling in his or her follow up elicitations more than 3 times. To me, no true pattern for telling appeared from this data. Perhaps the small number *N* (16) is the reason I was unable to see any patterns in intern practice related to telling. Or perhaps telling is less rampant in early interns' practice of eliciting and responding to student thinking than I had expected. If this is the case, then it is good news for teacher education. I detail my insights about this apparent lack of telling in early eliciting and responding to student thinking practice in greater detail in the discussion chapter.

Guiding. Guiding prompts seemed to be used much more when students answered correctly than when they gave an incorrect or non-response. In fact, almost 40% of correct student answers were followed-up with a guiding prompt. For example:

1. Allison (intern):	Yeah. One. Okay. Olivia, what do we get if we add one? Eddie just spun a one.
2. Olivia:	Um, 11. [correct]
3. Allison (intern):	Go ahead and write the equation. So we started at 11, so go ahead and write 11. Plus Eddie spun a one. So we're plus-ing how many?

After Olivia correctly states the sum of 11, Allison prompts Olivia to write the equation. Rather than waiting for Olivia to write the equation, Allison further guides Olivia by repeating the number 11 and indicating it should be Olivia's starting number for the equation. Then she continues to guide by stating, "Plus Eddie spun a one." Allison follows this statement with a question, asking, "so we're plus-ing how many?" I was interested to see that Allison is asking Olivia to repeat the very same information she just gave in her statement about Eddie's spin. Why did Allison scaffold Olivia's work so heavily? Since Olivia had just given a correct answer, I was expecting that this correct answer would give Allison confidence in Olivia and perhaps convince Allison to loosen the reins, so to speak, and let Olivia continue without being guided.

This finding, that interns would guide after a correct answer, was puzzling to me. I had hypothesized that interns would guide more heavily when students provided either an incorrect answer or no answer. I assumed that guiding would be used as a way to lead students toward the correct answer if they had not been able to provide the right answer in the second turn of talk. So, I was to find that when students did answer correctly in the second turn of talk, interns follow up with further guidance. Perhaps this continued guidance signals the interns desire to keep the flow of correct ideas coming. Or, perhaps interns are so concerned about students providing wrong answers that they stave off incorrect answers by over guiding in their follow-up responses. In any case, this finding seems important for teacher education. Knowing that early on in their eliciting and responding to student thinking practice pre-service teachers will over scaffold their students' responses by using guiding follow-ups, then preparation may need to address this habit and to support new and more skillful eliciting behaviors. I detail my suggestions for teacher education around this issue further in the discussion chapter.

Chi Square for 3rd Re-voice and No Follow-up Responses. Table 5-5 presents the 3rd turn categories of re-voicing and no follow-up elicitation in relation to student answers. Both categories were found to be statistically significant.

Table 5-5: Chi Square for 3rd Turn Re-voice and No Follow-up Responses

	Intern 3rd Turn Re-voice		Intern 3rd Turn No Follow-up	
Student 2nd Turn Answer:	n	%	n	%
Correct (n = 296)	54	18.2	21	7.1
Incorrect (n = 72)	18	25.0	1	1.4
Non-Response (n = 59)	3	5.1	3	5.1
$\chi 2$:				
F	8.851		6.086	
df+	2		2	
P	0.012*		0.0477*	

df+, degree of freedom
*P<0.05

Re-voicing. Re-voicing moves can be used for multiple purposes. According to Chapin et al. (2009) re-voicing can be used by the teacher to: (1) clarify what the student has said, especially when the teacher has not understood the student's meaning, (2) ask the student to verify the teacher's interpretation or re-voicing of what was said, (3) support other students in understanding what an individual student has contributed, and (4) extend a student's contribution connecting it to salient content or an example (p. 13-14). For this dissertation, re-voicing moves were used by interns for many of these purposes, and in response to all three types of student answers: correct, incorrect, and non-response.

There were very few cases of interns using re-voicing to follow-up a student's non-response. In fact, there were only 3 instances (5%) of student non-responses followed-up with an intern re-revoicing. In the following example, Kit attempts to clarify what her student, MJ, has said in his non-response answer to her initial elicitation.

1. Kit (intern):	What number did he get? He got a ten. All right, do the equation writing.
2. MJ:	It's the same thing as the other one? [non-response]
3. Kit (intern):	What other one?

MJ's answer is coded as non-response because he does not write the equation as elicited by Kit, nor does he verbally answer the question by stating the equation aloud. Instead, he answers her by posing his own question. In her response, Kit re-voices what MJ has said. She repeats the phrase, "other one" directly referencing what MJ has said in his second turn answer. In this case, Kit seems to be truly questioning what MJ is referring to. From the video record, I can not see if MJ is pointing to some "other one," but it is clear, from Kit's response, and her facial expression which can be seen on video, that she is unsure of what the "other one" is and is asking MJ to share his thinking with the group. In this case, Kit is re-voicing to clarify what the student has said, specifically because she has not understood her student's meaning.

In contrast to students' non-responses, about 18% of students' correct answers were met with a re-voicing move on the part of the intern. For example:

1. Allison (intern):	Okay, so we started with one, and he spun ten, so we're adding ten. What are we adding?
2. Eddie:	Ten. [correct]
3. Allison (intern):	Ten, okay. So you added ten to one. Right? What are you gonna write here?

In this example, Allison may be using a re-voicing move to draw attention to Eddie's correct answer, verifying that she heard him correctly report the "ten" and to support the other students in the group in understanding what Eddie has contributed. Further, she may be extending his answer of "ten" and connecting it to the 1 on the chart to create the equation that she references when asking, "What are you gonna write here?"

Although interns often re-voiced students' correct answers, I was surprised to find that more often, interns re-voiced students' incorrect answers. For example:

1. David (intern):	Another ten. Can you write the equation?
2. Aaron:	35 plus 10 is six—is 40. [incorrect]
3. David (intern):	40? Use the chart, then you'll know.

In this example David re-voices Aaron's incorrect answer of 40. When David revoices 40, his voice rises at the end indicating a question. He may be checking to see if he heard Aaron correctly. He further draws attention to the incorrectness of this answer by providing a direction for Aaron to use the chart to "know" the correct answer. In another example, Allison attempts to remediate her student's incorrect answer using a revoicing response.

1. Allison (intern): You spin—you spun a ten? Okay. What's our [fading voice 10:10]. He just spun a ten.

2. Olivia: Thirty-five plus one. [incorrect]

3. Allison (intern): Plus one? He spun a ten.

Perhaps interns are clarifying or verifying what the student has said as Chapin et al. (2009) states. But I believe the interns in this study were using a re-voicing move to remediate an incorrect student answer. Another possibility is because an intern is not sure how to respond to student incorrect answers, he or she is re-voicing, or repeating as a stall tactic to give him or herself time to formulate a better third turn response. In the case of this data, interns did not have many opportunities to respond to students' incorrect answers (72/427 or about 17%). This lack of opportunity may explain interns' less purposeful and more passive responses to students' incorrect answers.

No Follow-Up Response. Although there were cases where interns did not follow-up with a third turn response to a student's answer, these occasions were less prevalent in this data set. In fact, there were only 25 instances of no follow-up response out of 427 answers student gave during their second turn. Not surprisingly, the most typical kinds of student response that was met with no-follow up on the part of the intern, was a correct response. 21/25 (84%) of interns' no follow-up responses were after a correct student answer.

Summary

In this chapter, I have identified and defined common patterns of interns' enactment of the practice of eliciting and responding to student thinking during the third turn of talk. I describe four broad categories for these third turns of talk (1) elicitations, (2) leading prompts,

(3) re-voicing and repeating student contributions, and (4) no follow-up response. I also give examples of each of these from my data set. In the elicitations category, I further identify five specific types of third turn elicitations that: (1) focus on place value, (2) probe for student thinking or meaning, (3) link or apply to another representation, (4) consider other's thinking or work, and (5) make a prediction. Some of these kinds of elicitations rely on interns' knowledge of mathematics, such as focus on place value or linking and applying to another representation. Other elicitations rely on interns' knowledge of students and pedagogy, such as probing for meaning. Still other elicitations extend students thinking asking them to make predictions or connect their thinking to the thinking of others. In all five of these categories, interns are supporting student talk and thinking through the use of elicitations.

In the leading prompts category, I identify three types of leading prompts: (1) managing, (2) guiding, and (3) telling. Interestingly, this is the section of the analysis where I was able to notice some more nuanced features of these interns' early practice. They are still working on using wait time to allow students to answer questions, and refraining from telling students the correct answer or over scaffolding the cognitively demanding work.

All the findings from this chapter are further developed in the next chapter where I connect my results and interpretations to the larger body of teacher education research. I also detail the limitations of this dissertation research as well as the main contributions it makes in connection to potential directions for my future research.

Chapter 6

DISCUSSION AND IMPLICATIONS

Summary of Dissertation

Though student thinking is central to the work of ambitious teaching, and the practice of eliciting student thinking has gained recent attention in the field of mathematics education (e.g. Franke et al., 2007; Savage, 2010; Ing et al., 2015; Leatham et al., 2015; Lineback, 2015) what the practice looks like while being learned has not been well-specified in the research literature or in teacher education. A clear articulation of the work of eliciting and responding to student thinking is necessary for teaching novices how to do this unnatural and complex work. Many different bodies of literature inform an understanding of what comprises the work of eliciting student thinking, but unlike this dissertation, none focus on novices and their learning of the practice as the central object of study.

In this dissertation, I analyzed both the literature and data from preservice teachers' mathematics discussions to unpack the practice of eliciting and responding to student thinking. This analysis led to a detailed description of this group of novice teachers' early eliciting practice. I identified some of the more common and less common features of these novices' initial elicitations and responses to student contributions. In addition to decomposing novices' practice, I explored some of the possible reasons for the similarities and differences in the common features of their practice. These results contribute to the ongoing development of the knowledge base for teacher educators as they strive to support and train novices in the work of learning to enact ambitious teaching.

Main Findings and Contributions

I see two main findings in this dissertation study. The first main finding is the categorizations I developed in my analysis of interns' first turn elicitations and third turn responses to student answers. I want these categorizations to inform how teacher educators talk about, look at and evaluate preservice teachers' practice.

The second main finding is the way in which interns' enacted the practice of elisciting and responding to student thinking and how well, or less well, they oriented their teaching toward student thinking. As teacher educators, we help preservice teachers flip the switch and move to the other side of the desk in the service of skilled teaching. It is useful, as teacher educators, to know what preservice teachers bring to their teaching. In some cases, what they bring manifests in their practice as moves that can be refined or built upon. In other cases, preservice teachers may be forgetting or not knowing particular moves, which appear absent from their practice. Some may have habits that they need to curb or remove from their practice. These less-useful habits (e.g., guiding even when students have the correct answer, telling instead of eliciting thinking) need to be unlearned (Ball, 1998b). Shaughnessy and Boerst (in review) organize their findings around preservice teacher practice of eliciting student thinking in three clusters that have "implications for the design and conduct of teacher education, namely: (1) moves that require new learning, (2) moves that can be built upon, and (3) moves that may require unlearning" (p. 29). Following their lead, I present the patterns of interns' enactment of eliciting and responding to student thinking which I recognized in the data from this dissertation using Shaughnessy and Boerst's (in review) organization.

Moves that require new learning. In my analysis I note two aspects of intern practice that require new learning: (1) re-voicing student thinking and (2) not following up in response to student answers. By new learning, I mean the work of adding to an existing set of moves to further refine the practice of eliciting and responding to student thinking, making it more robust and reliable. Although interns in this study did employ the re-voicing student contributions, they primarily re-voiced correct answers. For example, Allison revoices Ty's correct answer of 32:

1. Allison (intern): Ten. Okay, what's total, Ty?
2. Ty: 32.
3. Allison (intern): 32, and how do we know 32 goes there?

In fact, 72% of interns re-voicing moves occurred in response to a correct student answer This behavior of revoicing correct student answers makes sense, given the cognitive complexity of responding to incorrect student contributions (Rybowiak, Garst, Frese, & Batinic, 1999; Tulis, 2013). Further, it potentially points to insecurity, on the part of early interns, in giving attention to incorrect answers. However, there is literature to suggest that incorrect answers may often reveal student sense-making and are useful in addressing misconceptions and common student errors (Schleppenbach, Flevares, Sims, & Perry, 2007; Stigler & Hiebert, 1999). Supporting preservice teachers in judiciously choosing particular incorrect student answers to re-voice and make the focus of discussion is an important part of the practice of eliciting and responding to student thinking. Doing so allows teachers to address misconceptions and build on student sense-making.

A second part of intern practice that could be added to and refined is choosing when to not follow up on a student's contribution. Although it may not be possible for teachers to respond to every verbal or written contribution a student makes, it is important to identify which contributions to take up during the course of instruction (Pierson, 2008). Similar to their choice of when and what to revoice, interns in this study tended to not follow up in response to student correct answers. Perhaps there would be occasions when it would be appropriate not to follow up in response to an incorrect student answer, or an answer that was unrelated to the task at hand. Regardless, it is important for teacher educators to support preservice teachers in purposefully making decisions about what they follow-up on and how they respond to student contributions.

Moves that can be built upon. There is one feature of intern practice that I identified in my analysis, which can be built upon: directing students' oral and written contributions in meaningful, but inconsistent ways. Moves that can be built upon are those that preservice teachers bring to teaching that can be "leveraged and built upon in teacher education" (Shaughnessy and Boerst, in review, p. 31). There are habits of behavior that do lend themselves to teaching. In particular are habits that Lortie (1975) claims "reaffirm" individuals in their choice to pursue teaching as a profession (p. 27). Organizing and leading are two such habits that appear to be central to the work of teaching. The preservice teachers in this study were able to direct students' oral and written contributions in meaningful ways during mathematics discussions. However, their directions and mode of direction giving were overwhelmingly inconsistent. For example, Zoe uses the word "spin" in the following initial elicitation:

1. Zoe (intern): Where is it on our number chart? Derrick. What did you spin?

24/27 interns used the word "spin" in at least one of their initial elicitations; yet all but 1 intern (96%) used the word "spin" in fewer than half of their initial elicitations. This inconsistency suggests that although preservice teachers bring ideas and competencies about directing or leading a discussion, they are unable to consistently employ teaching-specific moves (e.g., use of content vocabulary) in their practice of eliciting and responding to student thinking. Teacher education could learn from this insight, and thus devise rehearsals and teaching practicum around consistent use of teaching specific moves, like using and supporting student use of content specific vocabulary. This practice would be especially important in methods courses that are designed to address teaching in specific content areas (e.g., science teaching methods, or ELA teaching methods).

Moves that may require unlearning. I found two aspects of intern practice that may require unlearning: (1) telling rather than eliciting student thinking and (2) using a guiding prompt in response to correct student answers. By unlearning I refer to the habits and skills that preservice teachers bring to the work of teaching that may "undermine the work that teachers need to do" (Shaughnessy and Boerst, in review, p. 32; Ball, 1988b). Unfortunately, preservice teachers are not just bringing habits that are useful to teaching. They also bring conceptions and ways of knowing and acting that are not productive in teaching. It is necessary for them to unlearn these conceptions and behaviors in order to become skilled teachers.

In this study, teacher "telling" seems to be one of these habits that is not productive for teaching and needs to be unlearned. My analysis found that interns in this study responded to student answers by telling regardless of the accuracy (correct, incorrect, or non-response) of that student response. Instead of telling, preservice teachers must learn to elicit student thinking as a way to understand and build on students' existing fund of knowledge. Telling is a behavior that more commonly replaces teaching in daily life (Chazan and Ball, 1999). However, in classroom instruction and learning, telling does not serve the same purpose as teaching. Instead, teacher education must support preservice teachers in their practice of eliciting and responding to student thinking in lieu of telling students what to think. One place teacher education programs can begin this work is to have preservice teachers conduct student interviews. In student interviews, the teacher is focused on student thinking. Rather than focusing on teaching the student new information, these interviews serve as a way for preservice teachers to practice the work of learning about students, drawing out the conceptions and misconceptions of their students.

Another less productive habit that the interns in this study presented was the use of guiding prompts in response to students' correct answers. It makes sense that a teacher might provide some guidance when a student is headed down the wrong path toward an incorrect answer. Similarly, it would be reasonable for a teacher to guide a student who is struggling to produce an answer or complete a task. But the fact that the interns in this dissertation study were much more likely to use the leading prompt in response to students' correct answers is not only surprising but needs to be unlearned. For example:

1. Debbie (intern): 10. Okay, Heron. Write a number sentence. Okay, so Neil, close your eyes and let's see if we can—let's see if we can picture in our head the number sentence. 31—what'd you get Heron? Say it out loud so we can hear
2. Heron: Thirty-two plus 10 equals 42.
3. Debbie (intern): Okay. So I want you to show us where on our chart. We're at 32 and we added 10.

Although Heron's answer is correct, Debbie responds with an elicitation to connect to the hundreds chart, followed by a guiding prompt, "We're at 32 and we added 10." I had hypothesized that interns would guide more heavily when students provided either an incorrect answer or no answer, however, almost 60% of the time interns responded to student correct answers with a guiding prompt in their follow-up elicitation. When students provide correct answers, a more purposeful response would be to further elicit their thinking or meaning, or to connect their answer to other salient information within the content area. For example, if a student is able to add 20 in an equation, we might further probe the student's thinking to connect the equation to adding 20 using a visual model or representation (e.g., the hundreds chart). In the case of Debbie and Heron, a teacher educator could coach Debbie to follow up with, "Okay. So I want you to show us where on our chart," and then stop, providing no further information or guiding prompts. In fact, interns may need to practice letting an elicitation "breathe" and use wait time to avoid over scaffolding. Likewise choosing to re-voice a correct answer given by a student, or ask for a second student to consider the thinking of the first when asking for agreement is another possible response that does not include guiding the student toward the correct answer (Chapin et al., 2009). In both of these alternatives to guiding, preservice teachers need support in knowing what productive alternative moves exist and how to enact them in their teaching. It is the business of teacher education to describe these productive alternatives and to provide opportunities to practice these alternatives. This is the only way that teacher education can adequately support preservice teachers' switch to the other side of the desk as skilled teaching professionals. This dissertation focuses on the need to flip the switch and to move from student to teacher. The findings presented illustrate how knowledge of the skill with one core practice, eliciting and responding to student thinking, can be researched and connected to the work required in teacher education programs.

Limitations

Given the small number of participants (27) investigated in this study, it is unclear whether the interns or episodes presented here are typical of the larger population of early preservice teachers. Although patterns have emerged in the eliciting and responding to student thinking practice of this cohort of interns, the sample is too small to make broader claims about all beginning teachers. However, the large number of instances of elicitations and responses (442) suggests that patterns found could be used to characterize this cohort of interns and their early practice. Further, descriptions and examples from this large pool of examples could fruitfully be used in comparing and describing other cohorts of beginning teachers.

A second limitation of these findings is determining how specific they are to this population of graduate student interns and their students. Many teacher preparation programs in the United States are for undergraduate students, but this population is different. These participants are graduate students, who have completed a four-year college degree prior to enrolling in the program in which my research and data are based. My aim is not to define a particular trajectory for learning to elicit student thinking that is followed by all beginning teachers in all teacher preparation programs. However, I do strive to describe salient features of learning to elicit student thinking in mathematics in order to gain a better sense of how beginning teachers approach this work.

I was unable to perform a baseline assessment of the interns' ability to elicit student thinking prior to their beginning to teach in the preparation program. Since I have no knowledge of the interns' prior experience with eliciting thinking, working with elementary aged students, or engaging in mathematics, it is possible that the intern participants in my study have different levels of experience with eliciting individuals' thinking. This experience could be work or community based and may be with eliciting adult or children's thinking. For example, if one of the participants were formerly a police officer, might s/he have more experience eliciting individual's thinking from doing investigative tasks on the job? And might this experience impact the intern's eliciting practice from the very beginning of his or her preparation? I think a pre-course questionnaire that allowed interns to self-identify as people who have experience eliciting individual's thinking and responding to this thinking, may give me and other researchers access to some of the prior experience that preservice teachers bring to their preparation.

The third limitation of these findings is that I was unable to address the third facet of the practice of eliciting, interpreting and responding to student thinking: interpreting. From the data I collected, I was unable to reasonably make claims about their interpretations of student thinking. While there are some cases where I may be able to hypothesize about an intern's meaning from her or his elicitation, without actual reflection from or dialogue with interns, I do not feel I have evidence to support these hypotheses. In retrospect, I wish I had conducted and video recorded post-teaching interviews with each intern, eliciting their thinking about their eliciting practice, and how they were making sense of their students' thinking.

Next Steps in this Line of Work

In many ways, this dissertation is about setting the stage for future work. Conceptualizing the early eliciting and responding to student thinking practice of preservice teachers enables specific aspects (e.g., eliciting, re-voicing and telling) of novices' practice to be studied. The above discussion of this study's potential contributions to education scholarship points to a number of concrete next steps in this line of work. I briefly discuss four of these next steps in the following sections.

Additional teaching practices that would support this "switch to the other side of the desk." One next step would be to investigate other high-leverage practices that could give teacher education a window into shifts preservice teachers need to make in moving from the student side to the teacher side of the desk. As described in the introduction chapter of this dissertation, Lortie (1975) provides sociological analysis of preservice teachers who not very well positioned to becoming teachers since the majority of their experiences with schooling are in being a student. Building on Lortie's argument, Ball (1988a) investigates these experiences as students that preservice teachers bring to their preparation specifically addressing what preservice teachers think and believe and how these ideas influence their practice. Her argument is consistent with cognitive science, investigating preservice teachers' conceptions and prior conceptions. This dissertation extends past these conceptions and takes a close look at preservice teachers habits of behavior toward children from a learning perspective. I present examples of how preservice teachers enact teaching as a function of what they bring from their schooling and other experiences.

I assert that there may be some other high-leverage practices, that share traits with eliciting and responding to student thinking, which could offer teacher education insight into the necessary shift preservice teachers must make in moving from student to teacher. For example, the practice of *giving an explanation* might support the shift in orienting preservice teachers' thinking toward students. TeachingWorks provides a detailed explanation for the high-leverage practice they call *explaining and modeling content, practices, and strategies*:

> Explaining and modeling are practices for making a wide variety of content, academic practices, and strategies explicit to students. Depending on the topic and the instructional purpose, teachers might rely on simple verbal explanations, sometimes with accompanying examples or representations. In teaching more complex academic practices and strategies, such as an algorithm for carrying out a mathematical operation or the use of metacognition to improve reading comprehension, teachers might choose a more elaborate kind of explanation that we are calling "modeling." Modeling includes verbal explanation, but also thinking aloud and demonstrating.[9]

In their definition, TeachingWorks includes the work of coordinating verbal explanations with examples and representations in the work of modeling or giving an explanation. It is important

[9] http://www.teachingworks.org/work-of-teaching/high-leverage-practices

in this work is to orient the explanation to students. Given Lortie (1975) and Ball (1988a) I suspect that it is very likely that many preservice teachers, when enacting the practice of giving an explanation, would orient their explanations to what they think makes sense, rather than gearing their explanations to the thinking of students. How might teacher education support preservice teachers in enacting this practice of giving an explanation that attends to what students bring to school in terms of conceptions, prior conceptions and even misconceptions? This is a question I would be interested in pursuing in my future research.

Include interpreting student thinking to complement eliciting and responding to student thinking. A second next step would be to add *interpreting student thinking* to the early practices of eliciting and responding to student thinking. For this dissertation, the data did not allow for analysis of preservice teachers' interpreting of student thinking. Future research could investigate preservice teachers' interpreting of student thinking if post-teaching interviews were conducted, addressing teachers' interpretations of students' ideas and methods. In fact, TeachingWorks[10], a national organization dedicated to improving professional training for teaching, looks at eliciting along with interpreting and responding to student thinking. So there is a research-based reason to support the study of the three practices in connection to one another. Addressing novices' interpretations of student thinking may lead to further insights into the reasoning behind the kinds of early eliciting that preservice teachers employ. Additionally, interpretations could also lead to a better understanding of how and why novices give a particular third turn response to students' answers and could potentially result in further knowledge of the

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[10] http://www.teachingworks.org/work-of-teaching/high-leverage-practices#sthash.mJNroDoZ.dpuf

connection between preservice teachers' practices of eliciting, interpreting and responding to student thinking.

To include the interpreting in my investigation of eliciting and responding to student thinking I would want to carry out post-teaching cognitive interviews with preservice teachers (Desimone & Le Floch, 2004). During these interviews I would ask questions that specifically targeted what candidates were understanding about a student's answer during the second turn of talk, and how they were interpreting this understanding in order to respond to the student's contribution.

Study the practice of eliciting and responding to student thinking and its distribution in different contexts. A third step would be to study the practice of eliciting and responding to student thinking across different contexts. One context that is important and likely to require a different set of skills on the part of the teacher is teaching an English Language Learner (ELL) population. ELLs bring funds of knowledge to learning that is different from their English-speaking peers (Gutierrez & Rogoff, 2003). I wonder how might we adjust teacher education preparation to support novices in their eliciting and responding to students for whom English is not their first language? I noted in the methods chapter of this dissertation that the population of students that interns taught during the SSP were from diverse backgrounds. Many, in fact were ELL students who were still learning English. In many cases, these students' first language was not English, or English was not the primary language they were speaking at home. Given this larger population of ELL students, it would be beneficial if part of the training interns received during the SSP supported their teaching students in this population, especially when the task is to engage in a mathematics-based discussion (Moschkovich, 1999; Turkan, 2016).

Learning to teach a population of ELL students is especially salient given the current changing demographic in the United States. Current population trends reveal an increase in the number of Hispanic and Asian born children (Brown, 2014). In order to respond to the changing population of students in the United States, teacher preparation programs must support preservice teachers in learning how to effectively teach ELL students. It might be important to research how pre-service teachers elicit and respond to student thinking across language differences? Unfortunately, many current teacher preparation programs operate under the misunderstandings that: (a) the needs of ELLs do not differ significantly from those of other diverse learners, and (b) effective instruction for ELLs is primarily a menu of pedagogical adaptations (Harper and Jong, 2004). What is needed are specific understandings about students in ELL populations and teaching practices that will effectively reach and support learning for students who struggle with speaking and learning in English. Eliciting and responding to students thinking is a fertile site for attending to the differences ELL learners bring to classrooms because it is a practice that is oriented toward the student. Although some ELL students may speak very little English, others may be fluent, but may still be having some trouble in understanding and learning in English. I wonder: What does this mean about strategies for eliciting and responding to student thinking? It might mean teaching in a student's native language. But what if you, as the teacher, are not fluent in your student's native language?

How might your practice of eliciting and resending to student thinking change to best support ELLs? Perhaps teachers might be more thoughtful in their use of words, choosing words carefully so that these words might be understood. Teachers might reduce the complexity of the English that that they are using, purposefully using simpler words and simpler syntax. Equally, teachers eliciting and responding to ELLs might be more likely to use gestures or physical representations, like manipulatives and drawings in their practice. Given the mathematical terminology specific to this dissertation, I wonder how preservice teachers might support ELLs in understanding and using subject matter language like "equation" or "chart," during mathematics discussions. I could imagine a research study that focuses on this aspect of eliciting and responding to student thinking to better understand how teacher preparation can better support the early eliciting practice of novices in their work with ELLs.

Study the practice of eliciting and responding to student thinking over time. A fourth step would be to study the practice of eliciting and responding to student thinking over time. In this line of research I would investigate in one of two ways: (1) looking at preservice teachers' practice across the duration of their preparation program, or (2) looking at preservice teachers' practice at the beginning and end of their preparation and again during the mid-point of their first year of classroom teaching.

If I were to investigate the first approach within this same master's degree program, I would collect and analyze data from the interns' second semester of the program when they are enrolled in a second mathematics methods and content course and also engaged in teaching small group mathematics discussions weekly as part of this courses' practicum. In addition, I would collect and analyze small group mathematics discussions from interns' full-time student teaching placement that occurs during the winter semester of their preparation. Then, I would use the categories of eliciting and responding to student thinking that I have developed from this dissertation to compare interns' teaching practice across these three points in time (summer, fall, and winter semesters of their preparation program).

If I were to investigate the second approach, I would likely collect and analyze data from preservice teachers' mathematics discussions during their first semester of preparation and again, approximately one year later, during the first semester of their classroom teaching. I would choose to look at the practice after one year for two reasons. First, because this timing would give preservice teachers ample time to develop and change in their eliciting and responding to students' thinking practice. Second, because I wish to keep the focus on early practice to see how preservice teachers' early practice during teacher preparation compares to early practice during the first-year of teaching.

Conclusion

In conclusion, this dissertation set out to investigate one of the central practices of teaching: eliciting and responding to student thinking. Because this practice is so fundamental to the work of teaching, it is often taught to and enacted by preservice teachers early on in their preparation. Although the work of eliciting and responding to student thinking is central to the work of teaching, an orientation toward student thinking is not so common in beginning teachers. In fact, many early preservice teachers find it difficult to focus on other's thinking rather than their own. Specifically, teachers need to be able to elicit and respond to student thinking during instruction. Further, this study focuses on the early practice of preservice teachers, rather than looking at experienced teachers' more accomplished practice. In doing so, the research provides a much-needed picture of early eliciting and responding to student thinking practice. It does not supersede the current landscape of research on the practice of eliciting, but rather it specifies the description of the work of early preservice teachers. In more clearly articulating the practice of eliciting and responding to student thinking, this research contributes to the existing body of research on what it means to support teachers during their teacher preparation. The work of this dissertation further, informs the teacher education community in ways that support their work in training preservice teachers to elicit and respond to student thinking during mathematics discussion.

APPENDICES

Appendix A: Week 1 Curriculum for Making Ten Game

Protocol for Make Ten Game
SSP – Week 1

Planning the Activity

Instructional purpose:
- Learn as much as possible about what students know about complements of ten and about their general number sense
- Support students in figuring out strategies for making ten (complements of ten)

Mathematical goals:
- Subitize to recognize quantities less than ten
- Use the visual support of a ten frame to learn complements of ten
- Recognize there are multiple strategies for solving problems

Student participation goals:
- Explain their strategies for figuring out solutions
- Listen to each other, looking at the speaker
- Be prepared to paraphrase the speaker
- Take turns

Materials
- Six sets of ten-frame game cards for each intern
- A small white board on which to keep score
- A white board marker
- A paper towel or tissues to erase the white board

Preparing for the activity:
- Go into the classroom and discuss with your mentor teacher where you will be sitting with your group of students during rotations.
- Based on that location, determine the best place for you to set up your camera.
- Ask your mentor teacher how s/he would like you to help with *transitioning* students from the mini-lesson to the center where you will be working.
- Confirm how many students are in the class and how many you will be working with during your rotations. (The teacher will have half of the students in the class and the other half of the students will be split into two groups- one for you and one for another intern. You will work with approximately 4 students.)
- Have your "center" (either chairs or on the floor) set up in a semi-circle as much as possible so that students can see each other.

For three-intern teams

- You will rotate so that each of you will be working with a group for at least one rotation each day.
- When you are the observer, you will observe and take notes on students and on the way the activity is playing out. Your observations will be very helpful to our debriefing before rehearsals the following day.

Managing teaching challenges

- Consistently monitoring and reinforcing participation norms
- Helping students move from counting by ones to other strategies

Enactment	Notes and Cautious Points
Transition: *Make sure you're sitting where you will be able to do your best work. (i.e., not too close to a neighbor, not next to someone who will be distracting)*	Direct students to the places you want them to sit during your rotations. Day 1: They won't need to bring anything with them. Later in the week, if you decide you want them to write equations for ten, they will need to bring a pencil and their math notebooks to your group.
Introduce the task (game) to students *Let me see what it looks like when you are all STARs.* (Sit up. Track the speaker.) *Today we are going to play a game called Make Ten. All of you are on one team, and I'm on the other team, all by myself.* *I'm going to deal a <u>ten-frame card</u>, face down, to each of you.* *When I give a <u>silent signal</u>, you will turn over your card.* *I will ask you (1) how many dots you see on your card, (2) how you figured that out, and (3) how many more dots you need to make ten.* *There is one other rule to the game:* *Everyone else in the group must quietly look at and listen to the speaker while he or she is answering these questions.*	Make sure you have everyone's attention before you begin. Participation goals are incorporated into the rules of the game. Show a card, face up, to students. Decide what your silent signal will be and show it to students.
Scoring *This is how we keep score.* *I automatically get 5 points for each of you at the beginning the game. So before we start playing I will already have ___ (based on the number of students) points.* *After you answer the questions I ask you, you will earn 5 points for your team.*	

There is one more way you can earn points for your team: I will ask someone else on your team a question about your ten-frame. If that person can answer the question, s/he will earn 1 <u>bonus point</u> for your team. *Then I will go to the next person on your team and they will play.* *Oh, and I can give myself 5 points any time you are not following the rules of the game: answer the questions and look at and listen to the person speaking.*	(1) Ask one other student if he can <u>explain the first student's strategy in his own words</u>. If he can, he earns another point for the group. (2) Then ask one other student if she can <u>explain a strategy that is different from the shared strategy</u> for figuring out the number of dots on the card. If she can, she earns another point for the group. Use this sparingly. It will be more effective to keep the game going at a pace that will keep students engaged. You also want to keep the score close.
Model: *I will show you what I mean. First you all need to look at me and be ready to listen.* *(1) I see 6 dots.* *(2) I knew the top row was five because it was all filled in, then one more made 6.* *(3) I need 4 more to make ten.* *(4) I counted on: (6), 7, 8, 9, 10,) which was 4 more.*	Model these steps, e.g., with a 6+4 card. When explaining how you figured it out, combine a couple strategies e.g., <u>subitizing</u> 5, then <u>adding one more</u>, then <u>counting on</u> to ten
Check for understanding: *___, what are you supposed to do when I call on you?* *___, what does the rest of your team need to do while you are answering?* *___. how many points can you each win for your team?* *___, and what happens if you forget any of these rules?* *What questions do you have before we begin?* *Let's play!*	Have students restate the rules.
First round: *I will pass out a card to each of you; it will be face down. Don't touch your card until it's your turn and I tell you to. Just so you won't be tempted to take a peak, sit on your hands until it is your turn.*	To help students not look at their card until it's their turn, have them do something with their hands (sit on them, cross their arms, etc) Start the first round. Move at a steady pace from one student to the next to keep students engaged. After the first student has answered your questions, determine to whom you will ask the bonus questions

<table>
<tr><td colspan="2">Keeping score:
Add the score to the scoreboard after each student is finished.

<table>
<tr><td>Mr. Muller</td><td>3rd Graders</td></tr>
<tr><td>5 5 5</td><td>5 5 5 (+) 1 1</td></tr>
</table>
Have students skip count to determine the score at the end of the game.</td></tr>
<tr><td>Subsequent rounds
You really thought about your answers and paid careful attention to the person who was speaking.

Now we're going to play round 2. I will pass out a card to each of you…..</td><td>You get 5 points for each student at the beginning of the second round (and all subsequent rounds).

If you have students who are English Language Learners (ELL), you may need to explain the word "round".</td></tr>
<tr><td>Closing the task
That is all the time we have to today. What is the score of this round of the game? Who won the most rounds?

It was really interesting hearing all of the ways you talked about making ten. It was also wonderful to see how you listened to each other and made connections with what other people did.</td><td>State the main mathematical point(s) of the game and reinforce the participation goals.</td></tr>
</table>

Appendix B: Week 2 CUrriculum FOR Using Ten

Protocol for Using Ten: Quick images

Description

This activity is designed to provide additional opportunities for students to develop addition strategies focused on 10s. You will also continue to support students in explaining, using representations, and attending to the ideas of classmates. For this activity, you will flash a "double ten frame." This card has two tens frames on it and one of the two frames on the card will show 10, 9 or 8 dots. Totaling the number of dots on the two cards will support students in "using a ten" to determine basic addition facts. To support discussion of strategies you will use the sequence of questions that we rehearsed in class:

- **How many did you see?**
- **Did anyone see anything different?**
- **How did you figure that out?**
- **Did anyone see it a different way?**

After students discuss a double ten frame card, you will record the sum on a table you post on chart paper. The chart will look like this:

9 + =	10 + 1 =	8 + =
9 + =	10 + 2 =	8 + =
9 + =	10 + 3 =	8 + =
9 + =	10 + 4 =	8 + =
9 + =	10 + 5 =	8 + =
9 + =	10 + 6 =	8 + =
9 + =	10 + 7 =	8 + =
9 + =	10 + 8 =	8 + =
9 + =	10 + 9=	8 + =

Once a column in the table is filled in you will engage students in noticing patterns. Your questions to student will elicit their thinking about patterns in the sums, patterns in the addends, and patterns between the sums and addends. You will ask:

- **What do you notice about all of the equations in this column?**

You will ask for student ideas and should anticipate that someone will notice that each equation has a sum with a one in the tens place and a number in the ones place that is related to the addend being added to the ten/near ten (e.g. 8+5=13 The sum has a one in the tens place and 3 in the ones place, which is two less than the 5 that was initially added to the 8). This is a reasonable assumption, even though the question as phrased is quite open-ended, because the cards have been deliberately ordered to make this pattern stand out. Be prepared to have other students re-voice this strategy. This will help students see and understand how using ten can be helpful when they see a fact that has 10, 9, or 8. It also reinforces the importance of attending to the ideas of classmates.

You will also practice narrating your expectations for student participation in the activity by giving students clear, succinct directions. For example, at the end of the activity you will be asking students to work in their notebooks. Students will fill in the column of the table that you have them glue on a blank page in their notebooks. As part of this work you will direct students in putting their pencils down in preparation for the next pair of cards using phrases like, "Pencils down, track the speaker".

Protocol for Leading the Activity

Instructional Moves	**Considerations**
Prepping Students for Learning Direct students to bring their math notebooks and a pencil with them to your station. Do not begin the activity until you have arranged students where they will be able to see the cards and focus on participating in the activity. You may need to move students and should do this without hesitation. Eg. "Kayla, please move to this chair so you can see." Eg. "Jonathon, remember your STAR behavior. Please sit with your head up off of the table, ready to learn. (wait) Thank you." Eg. "You do not need your pencils now. Put them inside your notebook covers, please. (wait) I see that all but three are ready. Now two. Thank you!"	*You will need to work on finding your "firm" voice this week. Last week playing the game most of you mastered being "friendly" and enthusiastic. Now, we need to figure out how to balance "friendly and firm."* *You may also want a routine for managing the supplies that students will bring to the group. For instance:* - *Pencils inside notebook until it is time to write.* - *Turn the notebooks face down when not writing in them or being asked to use information they contain.* - *If students are on chairs they could put their notebooks under the chair when they are not writing in them.*
Introducing the Activity **Say**: Last week, we played a game together with ten-frame cards. Let's think about what we remember about ten-frame cards. "Tim, what's one thing you remember about ten-frames from last week?" *(Brief conversation – you may emphasize a row of five and two rows of five making ten if/when these ideas are shared)*	*Here you should use the tone of your voice and body language to create a little drama and suspense. Getting quiet and talking in a "stage whisper" would be one strategy. Leaning in and raising your eyebrows to emphasize "pair" or "really fast" would be another. While this is an opportunity to express your personal style, you all have a common purpose: to motivate students to participate. Use student responses to evaluate whether your "style" works with your students and adjust accordingly.*

***Fold one of the double frames in half and show student one frame that has all 10 spaces filled with dots**.*	
Say: I'll quickly flash a ten frame card and you can tell me what number you see. (do this one more time with a different ten frame)	*By "flash" we mean just show the card for 3 seconds like the mentor teachers have been doing with their Quick Image SSPdes.*
Say: Today, I'm going to show you pairs of ten-frames on a long card like this, but really fast. You have to be ready with STAR behavior, sitting up tall to track the card. Then, what do you think I'll ask you, after I flash the card really fast? *(Very quickly collect a few student ideas. Then…)* **Say**: Let's practice with a card. Ready…. (flash a double ten frame card that shows one full ten-frame along with one that isn't full)	*The point of flashing is to encourage subitizing strategies instead of counting every dot. You may need to experiment with how long to show the images initially in order to support this goal.* *If you notice that students are trying to count the dots during the flash, you may remind them that we are not counting. We are using what we know about tens frames to quickly know how many dots are on the card. This may be a place where you re-emphasize the two rows of five dots.*
Then ask: *(as rehearsed)* **How many did you see?** **Did anyone see anything different?** **How did you figure that out?** **Did anyone see it in a different way?**	*After students share a strategy or two you may want to allow them to look again at the card to support the conversation and explanations. For this look, you do not need to flash, but rather, hold the card up so that you and students can reference it when asking and answering questions.*
Next, you connect what the students saw to an equation on the table (on the chart paper). **Say:** Which equation in this column shows what we saw on the card? Why did you pick that equation? *While pointing at a number in the equation say…* Where is this number on the double ten frame card?	*Many of the questions and moves you used in last week's activity will be helpful when teaching Using Ten. For instance, asking students to make connections between numbers in the written equation to an image on the ten frame will again help students develop a understanding of what is shown in the equation.*
Proceed to flash the subset of the double ten frame cards that you planned (ones with a full ten on the first day, 9 on another day, or 8 on the next day). Ask the same sequence of questions for each pair. For each response record on the table asking the students where and what to record.	*Throughout your questioning, remind students to use the "quiet thumb" and to track the speaker. Weave in references affirming the STAR behavior that you see.* *If students notice patterns in the sums before the column in the table is completed you can acknowledge their contributions, but do not direct the students to talk about patterns until the column is finished.*

After you have flashed all the double ten frame cards and record all of the sums, ask students to analyze what they have just done by asking the open-ended question: **What do you notice about all of the equations in this column?** After you hear a few strategies, with at least one about how the addends relate to the sum, follow-up with the following questions to encourage strategic thinking **How could seeing that a card had a <u>full ten (or a near ten)</u> help you to figure out the total number of dots quickly?**	*Here you are engaging students in looking for patterns with the goal of students seeing that all of the pairs had a card with a full ten (or near a ten in later games).* *Given that you care about the strategy where addends relate to sums in a way that involves using tens, you will want to be prepared to ask at least two other students to re-voice and/or explain in their own words. However, students will notice other things and these should be validated, too.* *You may want to explicitly name the strategy "using ten strategy." Later when students are adding 9 or 8, it will help to repeat the idea that they are using their discovery about ten. Students learned that adding a ten easy (it is a "friendly number"). The 'using ten strategy' helps them make a ten to make it easier to add when one of the addends is 9 (or 8).*
In a table you have copied for putting in their notebooks, have students record the missing information in the column you have just completed. They should glue the table with the completed column into their notebooks. Then, mix up the cards and have students practice figuring out the number of dots on double ten frame cards using the "using ten strategy" in the time remaining.	*Do not ask students to explain their reasoning. You can quickly say how the strategy students just learned can be applied to the card. This sort of practice supports fluency with the strategy.* *A different activity would be to have students connecting a double ten frame that you flash with the equation on the chart. This has a different mathematical goal, namely to connect the dot representation with a symbolic notation of the equation. However, note that this is not helping students learn to apply the using ten strategy.*
<u>Closing the activity</u> That is all the time we have. What did we figure out today? By using tens we can figure out answers to addition problems pretty quickly and accurately. You found patterns and talked about helpful strategies. It was also wonderful to see how you listened to each other and made connections to what other people did.	*State the main mathematical point(s) of the game and reinforce the participation goals.*

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