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LEARNING TO ANTICIPATE STUDENTS' MATHEMATICAL RESPONSES IN TWO CONTEXTS: THE CASE OF ONE PRESERVICE TEACHER IN A UNIVERSITY AND SCHOOL SETTING

presented by

Sarah Elizabeth Kasten

has been accepted towards fulfillment
of the requirements for the

Doctoral degree in Mathematics Education

Major Professor's Signature

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Date

LEARNING TO ANTICIPATE STUDENTS' MATHEMATICAL RESPONSES IN TWO CONTEXTS: THE CASE OF ONE PRESERVICE TEACHER IN A UNIVERSITY AND SCHOOL SETTING

By

Sarah Elizabeth Kasten

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Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

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Mathematics Education

2009

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ABSTRACT

LEARNING TO ANTICIPATE STUDENTS' MATHEMATICAL RESPONSES IN TWO CONTEXTS: THE CASE OF ONE PRESERVICE TEACHER IN A UNIVERSITY AND SCHOOL SETTING

By

Sarah Elizabeth Kasten

Field experiences have been shown to impact mathematics preservice teachers' beliefs and perceptions about teaching and field experiences, but there is little research evidence of what preservice teachers learn about teaching mathematics from these experiences. This lack of research makes the mathematics field experiences a productive sight for investigation. Further research shows that mathematics preservice teachers struggle to consider their students possible reactions to the lesson plans they create as part of their participation in these experiences.

The purpose of this study was to trace the practices of anticipating students' mathematical responses of one preservice teacher in the first semester of her field experience and to examine the factors in the university and school contexts that supported or constrained her participation in this practice. Using a case study design, lesson plans and interview and observation data were collected and analyzed to present a picture of the practices of one preservice teacher working in two contexts. Findings indicated that there were multiple factors in the university context that promoted the preservice teacher in the practice of anticipating students' mathematical responses while lesson planning. Conversely, there were multiple factors in the school context that constrained her practices in this area. The findings also suggest that the preservice teacher in this study struggled to see the relevance of her own preferred teaching and lesson planning

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practices, those which aligned with what was advocated by the university, in the lecture-based school context in which she found herself. This study demonstrates the importance of preservice teachers having and making use of authority and resources in field experiences to support them in enacting their own practices as beginning teachers.

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I am so thankful for all of the graduate students I have had the opportunity to work with over the last four years. I am especially grateful to the members of my writing group, Lorraine Males and Aaron Brakoniecki, who read and gave feedback on my work and were always willing to help me with both technical and theoretical issues.

I especially want to thank my parents for being constant models of hard working, caring, and devoted teachers and scholars. Finally I want to thank my husband, Nick Pearson, for his constant love, support, and encouragement. This work would never have been possible without him.

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CHAPTER 1. INTRODUCTION

The purpose of this case study was to explore one preservice teacher's use of a lesson planning practice that was advocated by her teacher preparation program. This practice, anticipating students' mathematical responses to her lessons, was a strategy introduced and promoted by several of her university mathematics methods courses. This study sought to examine how she made use of anticipating in her field experience classroom and to identify the features of the university and school contexts that supported or constrained her ability to participate in this practice. The next sections provide a brief overview of the relevant research and a discussion of the contributions and limitations of the study.

1.1 The Role of Field Experiences in Teacher Education

Studies show that preservice teachers view the field experience as a major contributing factor to their learning in teacher education programs. Borko and Mayfield (1995) investigated the roles of cooperating teachers and university supervisors in a field experience in the learning of four preservice middle-school mathematics teachers. A portion of the study focused on the preservice teachers' perspectives about how one learns to teach and about their own learning during the field experience. The authors found that "all four student teachers expressed the belief that a person learns by doing—through experience, practice, and making mistakes" (p. 512). One preservice teacher in particular stated that in order to learn to teach one needs "experience. I think they can't teach you how to teach, no matter what anyone says" (p. 512). In addition, all four of the preservice teachers rep

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preservice teachers reported that the changes they made to the way they taught during their student teaching were based mostly on these experiences.

> The student teachers' comments about factors that influenced these changes paralleled, to a great extent, their ideas about how a person learns to teach. The factor mentioned most consistently was their classroom teaching experiences, "getting out there and doing it myself, seeing the problems, working with the students" (Ms. Richards). They also mentioned their cooperating teachers and, to a lesser extent, their university supervisors. (p. 513)

This finding is not true only of preservice teachers. Research conducted in the late 1980s indicated that practicing teachers also viewed experience teaching as the most significant factor in their learning. Smylie (1989) surveyed over 1700 teachers and asked them to evaluate a variety of experiences based on their effectiveness in supporting the development of knowledge and skills needed for teaching. Although teacher education field experiences were not among the experiences the teachers ranked, "findings indicate that, by far, teachers perceived direct experience in classrooms as their most effective source of learning" (p. 545).

More recent reviews of literature have supported these earlier findings. Wilson, Floden, and Ferrini-Mundy (2002) were commissioned by the Office of Educational Research and Improvement and the U.S. Department of Education to conduct a review of teacher education research. In reviewing research concerning the effects of student teaching the authors found that:

> Field experience is a staple of teacher preparation programs. Study after study shows that experienced and newly certified teachers see clinical experiences as a powerful—sometimes the most powerful—component of teacher preparation. Whether the power [of] field experience enhances the quality of teacher preparation, however, may depend on the particular experience. (p. 195)

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Even more recently the American Educational Research Association (AERA) Panel on Research and Teacher Education completed a volume summarizing research on teacher education. Their conclusions about the role of field experiences were similarly compelling.

> Field experiences have long been identified by both teacher educators and prospective and experienced teachers as a major, if not the most important, part of preservice teacher preparation. It is broadly assumed that field experiences are the key components of preparation where prospective teachers learn to bridge theory and practice, work with colleagues and families, and develop pedagogical and curricular strategies for meeting the learning needs of diverse populations. (Hollins & Guzman, 2005, p. 493)

The importance of field experiences has been even more elevated in universities that have chosen to include a fifth-year teaching internship experience as part of their teacher education program. Darling-Hammond (2000) describes this change in the structure of teacher education programs as being stimulated by the Holmes Group and other organizations. This restructuring of the traditional four-year teacher education program is intended to allow for:

> more extensive study of the disciplines to be taught along with education coursework that is integrated with more extensive clinical training in schools... because the 5th year allows students to devote their energies exclusively to the task of preparing to teach, such programs allow for year-long school-based clinical experiences that are woven together with coursework on learning and teaching. (Darling-Hammond, 2000, p. 167)

Studies suggest that increased time in a field experience may be beneficial for preservice teachers. Wilson, Floden, and Ferrini-Mundy (2002) described a study that compared a fifth year internship experience to a more traditional four year teacher education program. They report that findings indicated that the teachers in the fifth year internship program were more satisfied with their teacher education program, remained in the teaching profession lo

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A central feature of the field experience that makes it such a powerful venue for learning for preservice teachers is the constant access to students. "From field experience, prospective teachers reported acquiring survival skills, learning about students, and recognizing that their students' understandings vary, are complex, and differ from teachers" (Wilson, Floden, & Ferrini-Mundy, 2002, p. 196). Shulman (1986) describes a teacher's development of a variety of appropriate representations as one outcome of experience with students.

> Since there are no single most powerful forms of representation, the teacher must have at hand a veritable armamentarium of alternative forms of representation, some of which derive from research whereas others originate in the wisdom of practice. (p. 9)

Field experiences afford preservice teachers the opportunity to work with students and gain insight into useful representations, as described by Shulman, as well as other types of knowledge of students and student interactions with content.

The profound influence of the field experience indicates a critical need for teacher educators to know what preservice teachers learn from these experiences. A review of research from 1995 to 2002 by Clift and Brady (2005)[1] on the outcomes of field experiences for mathematics preservice teachers points to the current focus of recent research on changes in beliefs and not on what preservice teachers learn about teaching mathematics. Further, Clift and Brady reported that in the studies that investigated field

[1] Clift and Brady's review of research was part of a larger review of research on teacher education conducted by the AERA Panel on Research and Teacher Education.

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experiences, very few looked at the use of specific teaching methods within the experiences. As Wilson, Floden, and Ferrini-Mundy (2002) point out,

> The research on clinical experience is weak in several ways. Much of the early research focused on cooperating and prospective teachers' attitudes. Although it is important to know how teachers feel about the benefit of field experiences, attitude surveys do not answer questions about what prospective teachers actually learn" (pp. 196-197).

It is important for teacher education researchers to begin to focus their efforts on what is being learned by preservice teachers in this highly influential experience.

1.2 Studying the Role of Field Experiences from the Situative Perspective

Clift and Brady (2005) argued in their review of research of the impact of methods courses and field experiences that future studies in these areas must consider that "frameworks for research should move beyond behavior and cognition, beyond a limited focus on the individual (alone or in a group), and toward a more sophisticated knowledge of how practice is shaped by contexts, materials, and other people" (p. 335). In order to address Clift and Brady's suggestion, this study investigated the lesson planning practices of a preservice teacher from the situative perspective. Greeno (1998) defined *practices* as "regular patterns of activity in a community, in which individuals participate" (p. 6). In this study the lesson planning practice was a practice in which the preservice teachers at the university participated.

Greeno (1998) described one avenue for making use of the situative perspective to investigate the practices of the individual that also meets the standards for research in field experiences set by Clift and Brady.

> The other available strategy is to begin with the framework of the interactional studies and work inward. In this strategy, progress will occur by focusing on the

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> organization of intact activity systems and analyzing the informational contents of activity in which people accomplish the goals and functions of tasks they undertake. (Greeno, 1998, p. 6)

Field experiences are often the first time that preservice teachers have the opportunity to be part of and engage with a community of teachers as a peer. This community engagement makes the situative perspective particularly suited to the study of field experiences, which take place in the complex spaces of schools and universities and also in which preservice teachers participate in these contexts as both students and teachers. This perspective allowed this study to focus on the participation of a preservice teacher in a particular lesson planning practice in the field experience as well as to recognize and investigate the extensive contextual features of the environments in which she operated.

1.3 Teachers' Knowledge of Students

The recent work of Deborah Ball and her colleagues has focused on the knowledge that teachers need in order to teach mathematics. This work builds on the framework of teacher knowledge set forth by Lee Shulman in the mid 1980s. Shulman (1986) asserted that teachers needed not only content knowledge or pedagogical knowledge in isolation of one another, but a special combination of the two, which he termed *pedagogical content knowledge* (PCK). Since that time Ball and her colleagues have refined Shulman's knowledge domains into separate sub-domains and further specified them for mathematics. Among those in the domain of PCK is *knowledge of content and students* (KCS). In their work Hill, Ball, and Schilling (2008) define KCS and describe its importance for teaching mathematics:

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> We propose to define KCS as content knowledge intertwined with knowledge of how students think about, know, or learn this particular content. KCS is used in tasks of teaching that involve attending to both the specific content and something particular about learners, for instance, how students typically learn to add fractions and the mistakes or misconceptions that commonly arise during this process. In teaching students to add fractions, a teacher might be aware that students, who often have difficulty with the multiplicative nature of fractions, are likely to add the numerators and denominators of two fractions. Such knowledge might help her design instruction to address this likely issue. (p. 375)

In addition to field experiences serving as venues for preservice teachers to participate in a community of practicing teachers, they also serve as an initial and important opportunity to interact with students. As such, field experiences allow preservice teachers to learn from and about actual students as well as to make use of what they may already know. This includes knowledge of content and students as described by Hill, Ball, and Schilling (2008), who found in a review of literature that when teachers had access to knowledge about how students learned a particular subject matter that they changed their practices and student learning improved. The question then arises as to how preservice teachers learn about and consider for themselves this knowledge of content and students during their field experiences.

1.4 Anticipating Students Mathematical Responses as a Part of Lesson Planning

A primary focus of field experiences in teacher education is often the design and implementation of lesson plans. The National Research Council (NRC) (2001) addressed the important role of lesson planning by stating that "planning needs to reflect a deep and thorough consideration of the mathematical content of a lesson and of students' thinking and learning" (p.424). The NRC recommended that:

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> rather than simply listing problems and exercises, teachers should plan for instruction by focusing on the learning goals for their students, keeping in mind how the goals for each lesson fit with those of the past and future lessons. Their planning should anticipate the events in the lesson, the ways in which the students will respond, and how those responses can be used to further the lesson goals. (p. 425)

Despite the recommendations of the NRC and the attempts made by many teacher education courses, experience suggests that preservice teachers often do not recognize the importance of planning in the way the NRC describes, specifically in considering the possible reactions of their students as they plan. This practice is especially important for preservice teachers attempting to engage students in mathematics discussion as Stein, Engle, Smith, and Hughes (2008) explain:

> Without solid expectations for what is likely to happen, novices are regularly surprised by what students say and do, and therefore often do not know how to respond to students in the midst of a discussion. They feel out of control and unprepared. (p. 321)

Despite feeling more prepared when they have anticipated students' likely responses, considering how a middle- or high-school student will view the mathematics in a lesson can be difficult for preservice teachers, many of whom are themselves mathematics majors. Nathan and Petrosino (2003) referred to this problem of preservice teachers, and others with advanced-subject matter knowledge, as the "expert blind spot." Given a possible expert blind spot and their lack of personal experience teaching the content, it is important for preservice teachers to find ways to consider on their own as well as to seek out resources to gain access to knowledge of content and students.

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1.5 Contributions to the Field

This study is intended to contribute to the field of mathematics teacher education by building on prior studies about preservice teacher participation in field experiences. Specifically, it is informed by prior research and literature on preservice teacher learning in the context of field experiences (Mossgrove, 2006; Strawhecker, 2005; Vacc & Bright, 1999), the knowledge for teaching needed by a mathematics teacher (Even, 1993; Grossman, 1990; Hill, Ball, & Schilling, 2008; Kinach, 2002; Shulman, 1986, 1987), and the practice of anticipating students' mathematical responses (Carpenter, Fennema, & Franke, 1996; Carpenter, Fennema, Franke, Levi, & Empson, 2000; Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Chokshi & Fernandez, 2004; Fennema, Carpenter, & Peterson, n.d.; Fernandez, 2002; Hiebert & Stigler, 2000; Lampert, 2001; Leinhardt, 1988; Schoenfeld, 1998; Shen, Poppink, Cui, & Fan, 2007; Shimuzu, 2002; Stein, Engle, Smith, & Hughes, 2008). Additionally, this study is framed by the situative perspective on learning which has been used in the past to study secondary mathematics preservice teacher learning across a variety of contexts (Broadie, 2005; Engle, 2006; Greeno, 1998; Greeno, Collins, & Resnick, 1996; Peressini, Borko, Romagnano, Knuth, & Willis, 2004; Putnam & Borko, 2000).

While this previous work sheds light on teacher learning and knowledge in a variety of areas, researchers have not explored how experiences help preservice teachers participate in the practice of considering, or anticipating, their students' mathematical responses as they plan lessons in a field experience setting. This study sought to address this gap by presenting a case of a preservice teacher in a university field experience which focuses specifically on her development of the practice of anticipating students mathematical response

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1.6 Limitations

A limitation of this study should be acknowledged. Because this case study provides an in-depth picture of the practices and experiences of one preservice teacher it is limited in two ways. First, the findings may not be generalizable to other preservice teachers in other contexts. Second, because this research focuses on a single preservice teacher, comparisons of practices and school contexts are not possible.

1.7 Organization of the Dissertation

This dissertation is organized into six chapters. The first chapter provided an overview of the study. Chapter 2 details the relevant literature and lays out the framework and research questions used in this study. Chapter 3 outlines the methodology of the study. Chapter 4 describes the two primary contexts of the study, the university and the school. Chapter 5 presents the findings from the analysis of the data. Finally, Chapter 6 ncludes with a discuss

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CHAPTER 2. THEORETICAL FRAMEWORK AND REVIEW OF THE LITERATURE

This chapter outlines the existing educational theory and research as it relates to this study. The first section introduces a theoretical framework that describes the situative perspective on learning. This view of learning focuses on the contexts and the contextual features of learning environments and thus is well suited for studying learning within a field experience in which a myriad of factors interact to create the preservice teacher's experience.

The second section of this chapter reviews the relevant literature. This includes studies addressing the learning of preservice teachers in field experiences, specifically those related to learning to teach mathematics. This section also includes research in the area of lesson planning in order to frame common preservice teacher lesson planning practices. Additionally several frameworks related to the knowledge that teachers need to teach are presented along with summaries of three studies that examine the knowledge of preservice teachers preparing to teach mathematics. Finally, *anticipating students' mathematical responses*, a practice of mathematics teachers that is based on their knowledge of students, is described. The third and final section outlines the research framework developed for this study and introduces the research questions.

2.1 Theoretical Framework

In 2005 the AERA Panel on Research and Teacher Education released a report on the state of research in teacher education. In addition to reviewing the current teacher education research in this report, the panel also set forth recommendations for future research in teacher

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research in teacher education. Among these was the recommendation that future research should be situated in relation to relevant theoretical frameworks. The panel argued that doing so would aid researchers in explaining their findings about the effects of particular practices and "potentially contribute to the elaboration and refinement of these frameworks and to greater understanding of the process of teacher learning in different contexts" (Zeichner, 2005, p. 741). For these reasons the proposed study will be framed by a theoretical perspective on learning, namely the situative perspective.

The upcoming sections detail the theoretical framework for this study. The first section introduces the conceptual themes that underlie the situative perspective are described. The second section relates the situative perspective to other perspectives pertinent to this study. Finally, the third section summarizes two relevant studies. The first is a study of fifth-grade students participating in productive disciplinary engagement, a notion that closely resonates with the situative perspective. The second study is an exemplar of how the situative perspective has been used to study secondary mathematics preservice teachers (SMPTs) learning.

2.1.1 The Conceptual Themes of the Situative Perspective

The situative perspective is one of a variety of lenses that has been employed by educational researchers to study learning. In contrast to other perspectives, the "situative perspectives focus on interactive systems that include individuals as participants, interacting with each other as well as materials and representational systems" (Putnam & Borko, 2000, p. 4). Putnam and Borko summarize three conceptual themes that describe the situative perspective: (a) cognition as situated in particular social and physical contexts, (b) cogni

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contexts, (b) cognition as social and (c) cognition as distributed across the individual, other persons and tools.

The first of these themes, cognition as situated in particular social and physical contexts, asserts that both the activity and the environment are crucial to what is learned. Putnam and Borko (2000) explained that the activity must be authentic and provide the following definition: "J.S. Brown and colleagues (1989) defined authentic activities as 'the ordinary practices of a culture' (p. 34)—activities that are similar to what actual practitioners do" (p. 4). Field experiences in teacher education are intended to be authentic learning experiences in that they simulate the actual work of teaching by allowing preservice teachers to teach students in real classroom settings.

Given that the first theme focuses on learning situated within settings and activities, one issue that arises within the situative perspective is how to characterize the transfer of learning. In other views that focus on the individual's experience, transfer is typically seen as having the ability to apply a particular type of knowledge in different situations. For example, a student would apply their knowledge of subtraction learned in mathematics class to a situation of making change at the grocery store. The issue of transfer becomes problematic from the situative perspective because it is assumed that learning takes place within the situations in which the knowledge is to be used. Engle (2006) sheds some light on the issue of transfer from the situative perspective. She argues that "transfer is more likely to occur to the extent that learning and transfer contexts have been framed to create what is called *intercontextuality* between them. Intercontextuality occurs when two or more contexts become linked to one another" (p. 456). The key to linking two contexts acc

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linking two contexts according to Engle is to frame the learning context and transfer context as being connected to one another.

The second conceptual theme of the situative perspective is cognition as social. Just as the activity is central to the learning process, the social interactions that take place play a major role in what is learned.

> Interactions with other people in one's environment are major determinants of both what is learned and how learning takes place. The process of learning, too, is social. Indeed, some scholars have conceptualized learning as coming to know how to participate in the discourse and practices of a particular community. (Putnam & Borko, 2000, p. 5)

This means that all of the learners in a context impact the learning of the group and that the group is together working towards participating in the practices of a particular community. Preservice teachers in field experiences take part in a variety of social interactions in schools and university classrooms. Preservice teachers' working both of these contexts is a unique feature of this experience. The field experience serves as a transitional setting where preservice teachers are moving away from being part of a community of students toward being part of a community of teachers.

The third conceptual theme that makes up the situative perspective views cognition as distributed across the individual, other persons, and tools. Learning, thinking, and participation do not all rest with one individual or one tool; instead, a variety of resources contribute to the process. Putnam and Borko (2000) cite an example of this from Hutchins (1990) who describes the workings of a U.S. Navy ship.

> Six people with three different job descriptions and using several sophisticated cognitive tools were involved in piloting the ship out of the harbor. The distribution of cognition across people and tools made it possible for the crew to accomplish the cognitive tasks beyond the capabilities of any individual member. (p. 5)

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In a field experience a variety of people and resources are part of the preservice teacher's experience. In addition to what the preservice teacher brings to the experience, their mentor teachers, school resources, and university instructors share knowledge and experience with preservice teachers. Within this conceptual theme Putnam and Borko (2000) explain the importance of tools:

> In the world outside of school, intelligent activities often depend upon resources beyond the individuals themselves such as physical tools and notational systems (Pea, 1993). Many of these tools do not merely enhance cognition, they transform it; distributing cognition across persons and tools expends a system's capacity for innovation and invention. (p. 10)

Curriculum and other professional materials are examples of these tools that exist for teachers and are available to preservice teachers during field experiences.

The situative perspective is not the only perspective that can be used to study learning. The next section describes how the situative perspective can interact with other perspectives that have also been used to study teacher learning.

2.1.2 The Relationship between the Situative Perspective and Other Perspectives on Learning

The tenets of the situative perspective do not necessarily exclude other views of learning. In fact, in some cases, such as the sociocultural perspective, a relatively large overlap exists between the perspectives. The sociocultural view of learning, attributed to Vygotsky, gives priority to social interactions. Palincsar (1998) describes this view of Vygotsky's in the following way: "as learners participate in a broad range of joint activities and internalize the effects of working together, they acquire new strategies and knowledge of the world and culture" (p. 351-352).

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In her research with secondary mathematics preservice teachers (SMPT), Goos (2005b) drew on the sociocultural perspective to extend an existing framework that allowed her to study preservice teacher learning. Goos based her framework on Vygotsky's Zone of Proximal Development (ZPD) and Valsiner's (1997) extension of Vygotsky's work. Palinscar describes the ZPD as "what children can do with assistance" (Palincsar, 1998, p. 353). Valsiner used the extended framework "to explain children's development in the context of their relationships to physical environments and other human beings" (Goos, 2005b, p. 37) . Valsiner's framework includes two zones in addition to the ZPD, the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA). Goos further adapted this framework by applying it to teacher learning instead of student learning. Thus within her framework, the ZPD represents the "symbolic space where the novice teacher's emerging skills are developing under the guidance of more experienced people" (Goos, 2005b, p. 37). Included in this characterization of ZPD are the preservice teacher's skills and experiences working with technology, their pedagogical beliefs about technology integration, and their general pedagogical beliefs. The ZFM "suggests what teaching actions are *possible,*" and "might include their students (behavior, motivation, perceived abilities), curriculum and assessment requirements, and the availability of teaching resources" (Goos, 2005a, p. 2). Finally, the ZPA "represents the efforts of a teacher educator, supervising teacher, or more experienced teacher colleague to *promote* particular teaching skills or approaches" (Goos, 2005b, p. 38). Goos points out that it is possible for multiple ZPAs to exist if the actions promoted by the teacher educator are different than the actions promoted by the supervising teacher. Goos' framework allowed her to focus on the social and certain contextual features of

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The situative perspective can also be integrated with seemingly less related perspectives, such as the cognitive perspective. The cognitive perspective views knowledge as individual "understanding of concepts and theories in different subject matter domains and general cognitive abilities, such as reasoning, planning, solving problems, and comprehending language" (Greeno, Collins & Resnick, 1996, p. 16). Thus learning is seen as a "constructive process of conceptual growth" (Greeno, Collins, & Resnick, 1996, p. 16). Notable within this perspective is the work of Piaget who focused on the thinking of children. "Although cognitive structures could not be observed directly, as physical ones could, Piaget tried to reveal the thought processes of children through a technique of activity-based interviewing" (Resnick & Ford, 1981, p. 156).

According to Greeno (1998), the situative perspective accounts for aspects of learning that are invisible or ignored in other traditions while maintaining room for those perspectives' lenses within the theory. He argues that research embracing the situative perspective, which he refers to as interactional, and research employing the cognitive perspective need not operate in complete isolation, as they traditionally have. Greeno presents a method for taking into account both perspectives: "begin with the framework of interactional studies and work inward" (p. 6). Doing so could focus research on the organization of the situation and the community and also look inward at how individuals within those situations accomplish the tasks that make them part of the community. He explains then that "at a general level, the situative perspective subsumes the cognitive perspective by view

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perspective by viewing conceptual understanding, like behavioral skill, as an aspect of participation in social practice" (p. 17).

2.1.3 Examples of Research Employing the Situative Perspective

In the next two sections three studies are described that make use of the situative lens to investigate and describe learning. The first section described a study that looks at the notion of productive disciplinary engagement in a fifth grade classroom and argues that productive disciplinary engagement falls under the situative perspective by relating it to the conceptual themes previously discussed. Also in this section is a description of another study that shows how the principles of productive disciplinary engagement apply to the case of mathematics teacher learning. The second section presents a study that specifically identifies itself as an investigation using the situative perspective to study secondary mathematics preservice teacher (SMPT) learning.

2.1.3.1 A Study of Productive Disciplinary Engagement

The first study looks at the productive disciplinary engagement (PDE) of a group of fifth-grade students taking part in a science project. A group of students in the class was followed as they researched whales and eagles in order to answer an overarching question about how animals survive. Data was collected on the students' interactions within the group via observation and videotape.

The authors describe each part of PDE in turn. First, they explain engagement as the discourse of the participants in the group. Engagement thus looks at such questions as: "How are students participating? What proportion of students are participating? And how are students' contri

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how are students' contributions responsive to those of other students?" (p. 402). Thus engagement embodies aspects of the themes of both cognition as social and cognition and distributed. The authors go on to describe disciplinary engagement in a school context in the following way: "we mean that there is some contact between what students are doing and the issues and practices of a discipline's discourse" (p. 402). This part of PDE resonates with the conceptual theme that cognition is situated. The productive aspect of PDE is defined by Engle and Conant as the students actually getting somewhere in their work. In the case of their study this meant that changes occurred in the way students argued about science. While this does not address one of the previously discussed three themes specifically, it does resonate with the students coming to more fully participate in a particular practice of the domain.

After describing PDE, Engle and Conant (2002) present four principles that have emerged in their research as fostering PDE in groups of learners. Table 1 presents each of the four principles and provides brief descriptions of each.

Table 1. *The Four P*

Principle	
Problematizing content	
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Holding students accountable to other and to disciplinary norms	
Providing relevant resources	

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Table 1. *The Four Principles of Productive Disciplinary Engagement*

Principle	Description
Problematizing content	"problems do not need to be open from the perspective of experts in a discipline, but rather open from the perspective of the students interpreting them." (Engle & Conant, 2002, p. 404)
Giving students authority	"In general, by giving students authority, we mean that the tasks, teachers, and other members of the learning community generally encourage students to be authors and producers of knowledge, with ownership over it, rather than mere consumers of it." (Engle & Conant, 2002, p. 404)
Holding students accountable to others and to disciplinary norms	"This principle is an expression of the value that each member of the learning community is not an authority unto himself or herself, but one intellectual stakeholder among many in the classroom and beyond." (Engle & Conant, 2002, p. 405)
Providing relevant resources	"Resources supporting productive disciplinary engagement may be as fundamental as having enough time to pursue a problem in depth (Collins, 1998; Henningsen& Stein, 1997) or having access to sources of information relevant to it." (Engle & Conant, 2002, p. 405)

Using the case of the fifth grade science students researching and presenting an argument about different animals Engle and Conant (2002) show how these four principles emerged as fostering PDE. They then go on to illustrate how the principles were found in two other examples where PDE was present.

The principles of PDE can be found in examples of mathematics teacher learning as well those of student learning. Smith (2000) studied the dilemmas of one experienced teacher, Ms. Henderson, and traced how these dilemmas served as "springboards" for her learning. Ms. Henderson was in her twenty-seventh year of teaching but was in her first year using the *Visual Mathematics* (VM) curriculum. Her style of teaching was focused primarily on promoting student success, an idea that came into conflict with her new role as facilitator of student

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as facilitator of students' active construction of mathematics and mathematical explanations as prescribed by the VM curriculum. The study followed Ms. Henderson as she confronted this dilemma and "began to reorganize her ways of knowing in order to resolve the situation" (p. 353).

The extended professional development experience that Ms. Henderson engaged in prompted her to make changes to the way she thought about and enacted her role as a mathematics teacher. Engagement in this process displayed all four of the principles supporting PDE described by Engle and Conant (2002). First, the content, in this case mathematics teaching, was problematized for Ms. Henderson through her participation in the professional development experience. A dilemma "resulted from the tension between the teacher's past practice of structuring learning opportunities so that students could experience success and the new view that students needed to engage in complex problem solving that was often accompanied initially by feelings of being unsuccessful" (Smith, 2000, p. 358). Second, Ms. Henderson had the authority as the teacher in her classroom to make changes to her teaching practices. Additionally, she was supported in this by the presence of other mathematics teachers and administrators from her school who were also part of the professional development experience and responsive to engaging with her around the mathematics teaching practices at the school. Third, Ms. Henderson was held accountable to others and to the new disciplinary teaching norms through her involvement in the professional development community. After sharing an episode of her teaching one of the professional development staff "began to question the need to continue breaking things down for students" (Smith, 2000, p. 362). Finally, Ms. Henderson had access to relevant resources in the form of the new curriculum materials and the professional dev

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Smith's (2000) study is an example of a mathematics teacher participating in PDE of inquiry into her own mathematics teaching and also of the four principles that foster PDE described by Engle and Conant (2002). Although Smith did not specifically identify the principles in her study of Ms. Henderson, they were present in ways that contributed to her learning from her dilemma. The current study also makes use of these four principles to study the contexts that support or constrain the practices of a preservice mathematics teacher. The next section describes a study that detailed the learning experiences of secondary mathematics preservice teachers (SMPTs).

2.1.3.2 *A Study of SMPTs Learning*

The second study makes use of the situative perspective specifically to study the learning of SMPTs. Peressini, Borko, Romagnano, Knuth, and Willis (2004) investigated SMPTs learning to teach over time in a variety of contexts. They described their application of the situative perspective as follows:

> For teachers, learning occurs in many situations of practice. These include university mathematics and teacher-preparation courses, preparatory field experiences, and schools of employment. Situative perspectives argue that, to understand teacher learning, we must study it within these multiple contexts, taking into account both the individual teacher-learners and the physical and social systems in which they are participants (Putnam and Borko, 2000). (p. 69)

Their study reports on the use of a situative framework in the Learning to Teach Secondary Mathematics (LTSM) project that traced the learning of secondary mathematics teachers from their university experiences into their early years of teaching.

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Their research framework focused on three domains of professional knowledge: mathematics content, mathematics-specific pedagogy and professional identity. They looked at these domains across three settings: mathematics and teacher preparation courses, preservice field experiences, and schools of employment.

Using data from videotaped lessons, observation field notes, written artifacts and interviews with preservice teachers, cooperating teachers and university supervisors collected during the preservice teachers last years in a teacher education program and first two years in their own classrooms, the authors present two case studies that illustrate their application of the situative framework. The first case showed the development of one preservice teacher's complex notion of proof in her own mathematics learning and her teaching, tracing her development in the areas of mathematics content and mathematics-specific pedagogy. The second illustrated the struggle of a preservice teacher in the area of professional identity after leaving the teacher education program. The authors stated that the framework applied in this way was useful in tracing SMPT learning across the various contexts. In fact, when they encountered contradictory evidence "the framework enabled us to see these differences as coherent and sensible – as being integrally connected to norms and expectations specific to the different contexts, and to the novice teachers' evolving professional identities" (Peressini et al., 2004, p. 90).

In conclusion, the situative perspective can allow researchers to be concerned with contexts and environments as well as the participation of individuals within these settings. Studies using this perspective have identified principles that support learning from this perspective and have been used with the population that is of interest in this study. The next section presents a review of the literature relevant to the current study.

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2.2 Review of the Literature

The review of relevant literature for this study focuses on four main areas of research. The first is what preservice teachers learn about teaching mathematics from participating in field experiences. The second area of research is teacher lesson planning practices, an activity in which preservice teachers participate in field experiences. The third area of research in this section describes various views of teacher knowledge. The final area of research looks at the practice of anticipating students' mathematical responses, the activity that is the focus of this study.

2.2.1 Secondary Mathematics Preservice Teachers Learning to Teach Mathematics from Field Experiences

Field experiences are a major component of nearly all teacher education programs. Research has shown that field experiences can change preservice teachers' beliefs and has also focused on how preservice teachers perceive these experiences (e.g., Cady, Meier, & Lubinski, 2006, Philipp et al., 2007). Field experiences are unique in that they represent the most authentic set of activities available to preservice teachers learning to teach. The following section summarizes three studies that focus on what preservice teachers, both elementary and secondary, can learn about teaching mathematics from field experiences.

In the first of these studies, Strawhecker (2005) examined several different preparation treatments to determine which contributed most to preservice teachers' gain n Pedagogical Conten

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in *Pedagogical Content Knowledge* (PCK)[2]. Ninety-six elementary and middle preservice teachers at a small Midwestern university took part in four different semester-long preparation treatments. The first combined a content course, a methods course, and a field experience (CMF) and the second a methods course and field experience (MF). The other two treatments consisted of only one treatment, either a content course only (C) or a methods course only (M). Strawhecker used the Content Knowledge for Teaching Mathematics (CKTM) assessment to measure the PCK of the preservice teachers in each of the different preparations. The CKTM "represented a set of survey-based teaching problems thought to model various components of the specialized knowledge of mathematics which is needed for teaching" (p. 7). Although the author provided no details about the exact content of the CKTM, she explained that the survey had 27 multiple-choice items that integrated content knowledge, content knowledge situated in teaching, and knowledge of students' thinking ,which provided the researcher an overall PCK score for each participant. Strawhecker found that overall there were significant differences between the PCK of the four groups in favor of the two preparations with a combined methods component and field experience (CMF and MF). Although little detail was given about the exact nature of what was learned by the preservice teachers, Strawhecker's findings imply that field experiences can have a positive impact on the mathematical PCK of the preservice teachers.

The second study examined elementary preservice teachers' application of Cognitively Guided Instruction (CGI) methods, learned in a methods course, in their field experience classrooms. The authors describe CGI as "an approach to helping 'teachers

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use knowledge from cognitive science to make their own instructional decisions' (Carpenter & Fennema, 1991, p.10)" (Vacc & Bright, 1999, p. 90). Although this approach has been most often used in the professional development of in-service teachers, Vacc and Bright's application with preservice teachers would no doubt also contribute to their learning to teach mathematics. In fact, the characteristics of CGI teachers that Vacc and Bright describe could be considered positive outcomes for a teacher education program.

> Teachers who use CGI principles when teaching (a) believe that their understanding of children's thinking is a critical component of lesson planning, (b) facilitate children's problem solving and discussions of children's thinking, (c) listen to their children and question them until the students' thinking becomes clearer, and (d) are able to make instructional decisions that are appropriate to the mathematical needs of their students. (Vacc & Bright, 1999, p. 90)

Vacc and Bright constructed two case studies of preservice teachers and their experiences applying CGI in their field experience classrooms based on data from written work, observations of their teaching, and interviews with the preservice teachers.

The first case focused on Helen, a preservice teacher who stated that she began the methods course with the belief that "the teacher's role was to model problem solutions for students" (Vacc & Bright, 1999, p. 98). During her time teaching in the field experience Helen's beliefs shifted toward a more CGI-oriented approach and the authors found that to a certain extent she was applying CGI methods:

> She was fairly successful in applying some of these [CGI principles] during student teaching. She planned and implemented instruction that was based on problem solving, and she facilitated student understanding and critical thinking through a rather high level of questioning. (Vacc & Bright, 1999, p. 99)

In contrast, the preservice teacher Andrea, whose beliefs also shifted to a more CGI oriented approach, was not able to apply the CGI methods in her field classroom. "She appeared to focus more

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Vacc and Bright (1999) hypothesized that the differences in learning to apply CGI techniques during the field experience could have resulted from the influence of the mentor teachers. Helen's mentor had "extensive experience with CGI" but Andrea's mentor's experience "was limited to participation in a 2-hour 'awareness' workshop about CGI" (p. 93). From this the authors concluded that "if preservice teachers are to internalize coherent applications to teaching and learning mathematics, the environment in which they student teach and the support they receive need to be consistent with the principles being advocated in their professional preparation program" (p. 109). This study highlights the important role of the mentor teaching in the application of university promoted practices by the preservice teachers.

The final study, by Mossgrove (2006), looked at the planning practices of two secondary preservice teachers, Paige and Keith, and their use of instructional tasks in their field experience classrooms. Specifically, she examined the opportunities each of the preservice teachers had to learn about student-centered instructional practices. Mossgrove found that the curriculum used by each preservice teacher contributed to their learning of teaching mathematics:

> An analysis of the contextual settings in which Paige and Keith worked point to key differences in the opportunities that Paige and Keith had during their field experiences to learn about student centered instructional practices...Keith was greatly influenced by his use of a reform-oriented curriculum, whereas Paige did not have access to such a curriculum. (p. 5)

The settings for Paige and Keith's field experiences were quite similar, but as the quote above indicates, their exposure to curriculum was not. Paige taught several sections of a course called Integ

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of a course called Integrated One using a curriculum published by McDougal Littell. Keith taught 6th and 7th grade mathematics classes as well as an algebra class for advanced 8th grade students. In his 6th and 7th grade classes Keith used Connected Mathematics (CMP) as the curriculum and in his algebra class he used Prentice Hall Algebra I.

Mossgrove (2006) focused her data collection for Keith on his algebra class but found that his teaching of CMP in the other classes impacted his lesson planning in algebra. Keith changed the Prentice Hall lessons in order to "let the students make some sort of discovery and then talk about it as a class" (p. 164-165). Keith's mentor teacher referred to this practice of modifying lessons as "CMP it." The result was that Keith learned how to modify lessons from more traditional texts to make them more student centered. Paige did not have this opportunity and stayed close to the curriculum in planning lessons for her class. Thus, based on the experience in her field placement Paige had less of an opportunity to learn about creating and implementing student-centered lessons.

Although field experiences play such a major role in the preparation of teachers, there is relatively little evidence of what secondary mathematics preservice teachers learn from the experience about teaching mathematics. Strawhecker (2005) found that field experiences had an impact on the PCK of elementary and middle school preservice teachers, more so than methods courses or content courses alone. Although these findings are promising, little detail was provided about the exact nature of the PCK or what happened in the field experiences and methods courses that contributed to PCK. The other two studies (Mossgrove, 2006; Vacc & Bright, 1999) showed the importance of the mentor teacher and cur

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mentor teacher and curriculum in what the preservice teachers were able to learn about teaching mathematics from the field experience. These studies provide pictures of teacher learning in authentic experience (i.e., field experiences) and accentuate the importance of the role of context in what is learned by preservice teachers. The next section summarizes research around a specific practice of teachers, one that preservice teachers participate in during field experiences, namely lesson planning.

2.2.2 Teacher Lesson Planning

Teacher lesson planning has been a site of educational research for a relatively long period of time in the education research community. A review of research by Shavelson (1983) on teachers' pedagogical judgments, plans, and decisions sheds light on findings from research conducted from the late 1960s to the early 1980s. This early research with teachers in a variety of content areas pointed to the importance of well-developed and thought-out lesson plans. "Plans exert such a strong influence on teachers that teachers tend not to deviate from them once they have begun teaching" (Shavelson, 1983, p. 401). In addition to the importance of the lesson plans, Shavelson reported that research showed that teacher planning focused on choosing classroom activities instead of using the model that many were trained to use: "specifying behavior objectives, specifying students' entering knowledge and skills, selecting and sequencing learning activities so that students accomplish objectives, and evaluating the outcomes of instruction in order to improve planning" (p. 402).

The studies reviewed by Shavelson (1983) made use of a variety of methods to collect data about teacher lesson planning practices. These methods included questionnaires, intervie

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questionnaires, interviews, ethnography, simulations, and "think aloud" protocols. Overall, the findings from the studies suggested that when planning lessons, teachers were concerned with students and subject matter, although less so with the structure of the subject matter. Despite their concern with students, two studies were described that showed how lesson planning could actually detract from students learning. Shavelson reported that these studies suggested that lesson planning "may be counter productive if teachers become single-minded and do not adapt their lessons to students needs" (p. 405).

Some research conducted after the studies on lesson planning reviewed by Shavelson (1983) took the form of expert-novice comparisons. As one example, Borko and Livingston (1989) examined the differences between expert and novice mathematics teachers in three areas: planning, teaching, and post lesson reflections. The three novice teachers in their study, one elementary and two secondary, and their mentor teachers were interviewed before and after teaching lessons and observed for one week to examine their practices in these three areas.

Borko and Livingston (1989) found that there were differences in the ways that the novice and expert teachers planned their lessons. The expert teachers planned on several different levels including yearly planning, unit or chapter planning, and daily planning. Although most of the expert teachers' lesson planning occurred outside of the formal school day and was not written down, they each described detailed mental plans.

> Reported plans typically included a general sequence of lesson components and content. They did not include details such as timing, pacing, and the exact number of examples and problems, these aspects of instruction were determined during the class session on the basis of student questions and responses. In fact, when asked what would be happening in class each day, [two of the expert teachers] typically described plans that explicitly anticipated contingencies that were dependent on student performances. (Borko & Livingston, 1989, p. 480)

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In contrast, the novice teachers' planning was more focused on the short term. The authors offered several possible explanations for their differing focus. First, the novice teachers were only in the class for 12 weeks beginning in January. Because of this timing, planning at the year and even the semester level had already been completed. Second, one of the novice teachers noted that the amount of time and energy it took her to plan lessons meant that she was only able to plan for the next day. Finally, another of the novice teachers felt constrained in this area by her mentor teacher. "Since I'm kind of like in [his] system, I'm just going by what he wants done...He basically has said, 'Do a page a day.' So that is kind of what I'm going on and I haven't stepped back" (Borko & Livingston, 1989, p. 486).

Another feature of the novice teachers' lesson planning was that it primarily focused on how they would represent the mathematical content to students and creating detailed presentation plans. The novice teachers mainly drew on the teacher's manual, their mentor teachers' notes, and their own learning experiences to create their plans. For the novice teachers, "the process of creating a mental script for presenting the lesson content was time consuming and often appeared inefficient" (Borko & Livingston, 1989, p. 486). In addition to planning their presentation of the material, the two secondary novice teachers also included working out the problems in their daily planning process. Although both had access to the problem solutions, one of these novice teachers explained that "without going through this process it was not possible to 'own the problem solution'" (Borko & Livingston, 1989, p. 487).

A final feature of the novice teachers' lesson planning was that it lacked the experience that the expert teachers were able to draw on. All three of the novice teachers reported wanting to try

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reported wanting to try using less traditional teaching formats but all felt unready to try something they had little or no experience doing. The novice teachers also lacked experience with student reactions to the content. "All three reported being unable to predict where in the curriculum students would have difficulty" (Borko & Livingston, 1989, p. 487). In addition to the novice teachers concern about their own lack of experience in this area, the authors found that when they enacted their lessons "all three ran into problems when student questions or comments led them to attempt explanations not prepared in advance" (Borko & Livingston, 1989, p. 487).

Based on their findings of the novice and expert teachers, planning, teaching, and reflection, Borko and Livingston (1989) offer several explanations for the difference which lead them to make recommendations for field experiences and the final student teaching experience in particular. Borko and Livingston explain that it was the fact that it was the novice teachers' first time teaching the content more so than that it was their first time teaching in general that limited their lesson planning.

> Several of the difficulties the novice teachers encountered, such as the time-consuming nature of their planning and the inability to anticipate student problem, are difficulties encountered by most teachers the first time they teach a course or body of knowledge. Any teacher will think and act like a novice, to some extent, the first time he or she attempts to teach a particular body of knowledge. (Borko & Livingston, 1989, p. 489)

Based on this explanation and others, Borko and Livingston offer several recommendations to remedy the situation: (1) novice teachers should take a reduced teaching load to afford more time for better planning, (2) novice teachers should teach content they are very familiar with in order to free them to use their time to plan their presentation instead of learning the content, and (3) novice teachers should be provided multiple opportunities to teach the same content so that they can immediately make changes to their less

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2.2.3 Knowledge for Teaching Mathematics

Discussions of what teachers need to know to teach mathematics are prevalent in the current research literature. Many of these discussions are based on the assumption that mathematics content knowledge alone is not sufficient to assure effective teaching of mathematics. Though many share this assumption, the exact knowledge necessary for a mathematics teacher is not a settled issue and is characterized in different ways by different authors. This section details the work of Shulman (1986, 1987), Grossman (1990), and Ball and colleagues in this area.

2.2.3.1 Shulman's Framework for Teacher Knowledge

One of the most classical characterizations of teacher knowledge is described by Shulman (1986). He begins the argument for a framework for teacher knowledge that takes into account content and pedagogy with a historical perspective on the knowledge deemed necessary to be a teacher. In the 1800s and early 1900s the focus on teacher knowledge was on content alone, but by the 1980s the emphasis on teacher knowledge shifted to pedagogy. Shulman argues that both types of knowledge are important for teachers and that one should not be focused on to the exclusion of the other. To address this need for a dual focus, Shulman presents a theoretical framework with three types of knowledge for teaching: (1) Content Knowledge, (2) Pedagogical Content Knowledge and (3) Curricular Knowledge. He further refined this framework in 1987 to include a tal of seven differ

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total of seven different types of teacher knowledge. This formulation of the framework additionally included: general pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational ends, purposes, and values. Because this section of the literature review only focuses on pedagogical content knowledge and characterizations of teacher knowledge that build on it, only the three types of knowledge included in Shulman's original framework will be discussed here.

The first type of teacher knowledge included in Shulman's (1986) framework is content knowledge. The content knowledge Shulman describes as being necessary for teacher requires more than a simple understanding of subject matter.

> To think properly about content knowledge requires going beyond knowledge of the facts or concepts of a domain. It requires understanding of the structure of the subject matter...Teachers must not only be capable of defining for students the accepted truths in a domain. They must also be able to explain why a particular proposition is deemed warranted, why it is worth knowing, and how it relates to other propositions, both within the discipline and without, both in theory and in practice. (Shulman, 1986, p. 9)

Thus, a teacher of mathematics needs to know how to do mathematics but also how mathematics as a discipline is structured and functions, both in its content and processes.

The second type of knowledge in Shulman's (1986) framework is pedagogical content knowledge (PCK) which is described as going "beyond knowledge of subject matter per se to the dimension of subject matter knowledge *for teaching*" (p. 9). Shulman further clarified this component of his framework:

> Within the category of pedagogical content knowledge I include... the ways of representing and formulating the subject that make it comprehensible to others. Since there are no single most powerful forms of representation, the teacher must have at hand a veritable armamentarium of alternative forms of representation, some of which derive from research whereas others originate in the wisdom of practice. Pedagogical content knowledge also includes an understanding of what

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> makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons. (p. 9)

Thus, PCK includes a teacher's knowledge of the ways that students may interact with the mathematics they are learning.

The final component of Shulman's (1986) original framework, curricular knowledge, has received little attention compared to the other two components. Shulman describes curricular knowledge as knowledge of

> the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances. (p. 10)

Shulman points out that even more than PCK, which was not a focus of teacher education programs at the time he presented his framework, curricular knowledge was absent from the university teacher education curriculum.

Putnam and Borko's (2000) review of literature on learning to teach included research on the PCK of preservice teachers. They report that in general novice teachers

> enter the classroom as a teacher for the first time with little information about who their students are or what they know about subject matter being taught. This lack of information affects their ability to design appropriate instruction...There is little research evidence concerning novice teachers' knowledge of specific understandings and misunderstandings that children have about particular subject matter content. Additional research is needed to explore how novice (and experienced) teachers can be helped to acquire such knowledge. (p. 692)

This study seeks to contribute to this area by examining how one preservice teacher in a field experience learns to consider what her students know during her lesson planning process. The next section summarizes two studies that explore the existing PCK of secondary mathemat

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2.2.3.2 Studies Examining the PCK of Secondary Mathematics Preservice Teachers

Despite the fact that studies and discussion of PCK are relatively prevalent in the literature, there are surprisingly few studies that look at PCK in relation to SMPTs. Currently, there appears to be more inquiry into the mathematical PCK of elementary preservice teachers and practicing teachers. Three studies that do examine PCK with respect to SMPTs were conducted by Even (1993), Pitts (2003), and Kinach (2002). All of the studies consider PCK in terms of the mathematical explanations the SMPTs provide about specific content.

Even (1993) examined the relationship between SMPTs content knowledge and PCK in the area of function. Specifically, Even was interested in whether the preservice teachers evidenced knowledge of the two essential features of the modern definition of function, namely arbitrariness and univalence. Definitions that did not take into account the arbitrary nature of functions were characterized as "old." For this study PCK was defined as "knowing the ways of representing and formulating the subject matter that makes it comprehensible to others as well as understanding what makes the learning of specific topics easy or difficult" (p. 94-95). Data was collected via questionnaires completed by 152 SMPTs and 10 follow-up interviews.

Even (1993) found that when asked to give a definition of function only 78 of the 152 participants were able to supply a modern definition, while 53 supplied an old definition, 11 other definitions (some kind of a rule, such as the vertical line test, instead of a definition), and 1

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of a definition), and 10 provided no response. In contrast, when asked to give a definition that they would present to a student with difficulties understanding the definition of function only 27 of the 152 SMPTs came up with a modern definition. Sixty-seven of the participants gave an old definition, 36 other definitions, and 22 gave no response. These findings indicate that many of the SPMTs in the study did not have a modern conception of function and that many of those that did not have sufficient PCK to construct a modern definition of function for students. Even posits that the lack of attention to univalent property of functions might lead SMPTs to focus more on procedural understanding of function than meaning. "That is exactly what many of the prospective teachers in this study did when choosing to provide the students with the 'vertical line test' as a rule to follow and get the right answers without concern for understanding" (p. 112). Even's findings indicate that for the SMPTs in her study, having adequate content knowledge of function did not guarantee fully developed PCK, because not all of the SMPTs with a modern definition of function were able to represent it in the modern form or with meaning in definitions for students.

Another study that looked at content knowledge and PCK of SMPTs in the area of function was conducted by Pitts (2003). Pitts examined these two types of knowledge with respect to making translations between algebraic and graphical representations of functions. Using a two part questionnaire completed by 59 SMPTs Pitts gathered data about (1) how the SMPTs approached problems that called for translations, (2) examined students' responses to problems that called for translations, and (3) attempted to address students' misconceptions concerning problems that called for translations. To analyze the

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responses from the questionnaire Pitts identified the approaches the SMPTs were taking to translations as process oriented, object oriented, both, or neither.

In looking at the preservice teachers approaches to translation problems in the first part of the survey, Pitts (2003) found that 90% of the participants in her study had a dynamic mental model of translations. That is, their mental models of function were comprised of both process and object orientations and she further found that many of the preservice teachers were able to move freely between the two perspectives. When analyzing student work in the second part of the questionnaire the preservice teachers were asked how they thought the students were thinking about the representations. As with the first part of the questionnaire, their responses were coded as process, object, both, or neither. Pitts found that the preservice teachers' mental models of the students thinking were usually accurate when either a process or object orientation was present in the students' responses. However, almost 40% of the overall responses were coded as neither process nor object. Finally, the preservice teachers were asked if they saw any misunderstandings, or misconceptions, in the students' responses in the second part of the questionnaire and if so how they would address these misunderstandings, or misconceptions. Looking at how the preservice teachers' explanations of how they would address the misunderstandings, or misconceptions, Pitts found that more than half of the explanations, what she referred to as pedagogical approaches, offered made use of neither the process or object models, even when the preservice teacher had used the model to solve similar problems themselves. Pitts findings indicate that there are differences between preservice teachers content knowledge that they use to solve mathematical problems themselves a

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The final study of SMPTs PCK addresses a content area different than the first two, namely the subtraction of integers. Kinach (2002) explored the content knowledge as well as the PCK of 21 SMPTs in terms of Skemp's (1978) instrumental and relational understanding. Using three tasks about integer subtraction and discussions and reflections around those tasks, Kinach challenged the SMPTs' thinking about their own understanding of integer subtraction and about how their future students might receive their explanations of integer subtraction. Each task called on the SMPTs to construct an explanation about integer subtraction. The first specified no context, the second a number line context and the third an algebra tile context. As the SMPTs developed and discussed their explanations they saw that their original explanations, and in fact their own understandings, were more instrumental than the later explanations in context. Kinach concluded that her strategy for transforming the PCK of the SMPTs was useful and that it could be employed for other content.

> Beyond providing these specific mathematical insights into changes in the prospective teachers' PCK and SMK [subject-matter knowledge] for the example of addition and subtraction of integers, the results of the present study refine our understanding of the transformation process itself. (Kinach, 2002, p. 64)

All three of these studies shed light on the relationship between SMPTs' content knowledge and their PCK. The authors of these studies all examined PCK using the preservice teachers' mathematical explanations. This particular type of PCK has been characterized by Grossman (1990) as knowledge of instructional strategies[3]. Even (1993) found that a "modern" understanding of function did not ensure "modern" mathematical

[3] A complete outline of Grossman's PCK framework can be found in the next section.

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explanations of function. Similarly, Pitts (2003) found that the dynamic mental models of translations (representing both the product and object perspective) did not guarantee the explanations of translation were dynamic or in fact would include either a process or object characterization of function. And Kinach (2002) showed that the type of content knowledge, either relational or instrumental, impacted the resulting mathematical explanations and that through carefully designed assignments preservice teachers were able to recognize the limitations of their explanations and to develop explanations that were more relational. The next section provides an overview of Grossman's four forms of PCK as they appear in her model of teacher knowledge, and highlights one of them as representing the type of PCK being examined in this study.

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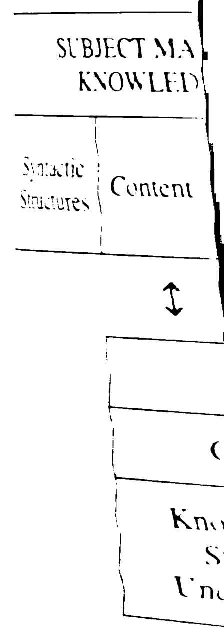

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2.2.3.3 Grossman's Model of Teacher Knowledge

Grossman's (1990) model of teacher knowledge builds on Shulman's (1986) framework of the knowledge needed for teaching (Figure 1).

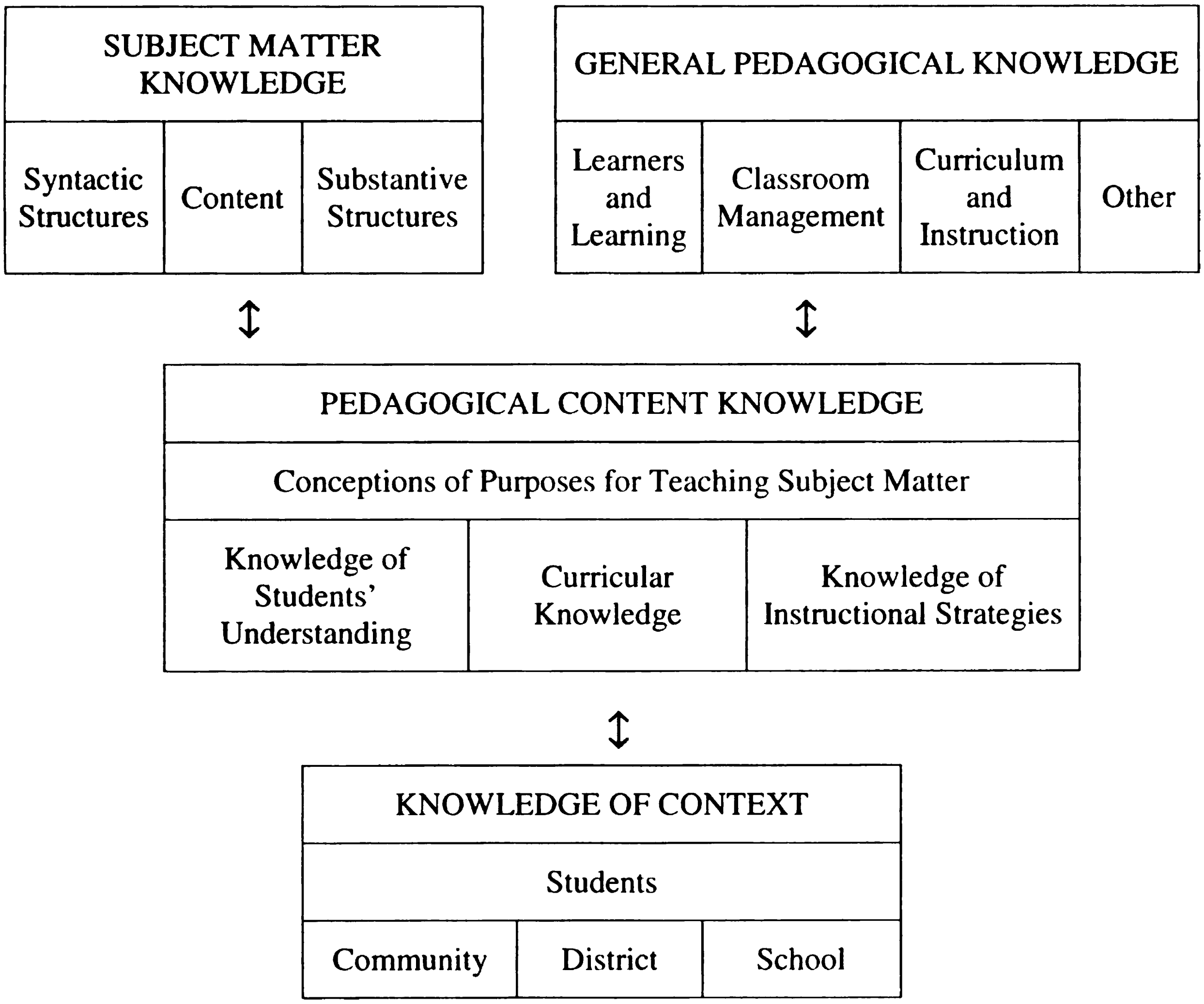

Figure 1. Grossman (1990) Model of Teacher Knowledge

The first component of PCK in Grossman's model comprises of the conceptions teachers hold about the purposes for teaching a subject at different grade levels. Grossman states that conceptions are represented by the teachers' goals for teaching particular subject matter. The second component, knowledge of students understanding, includes knowledge of conceptions and misconceptions of particular subject matter. Grossman explains that "to gene

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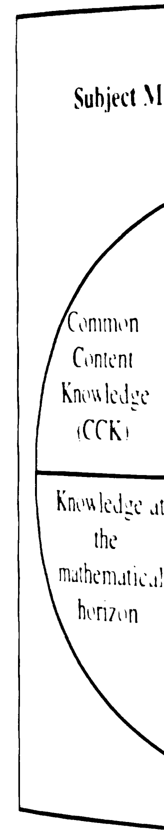
explains that "to generate appropriate explanations and representations, teachers must have some knowledge about what students already know and what they are likely to find puzzling" (p. 8). This type of teacher knowledge is the focus of this study. The next section describes how Deborah Ball and her colleagues have also built on Shulman's PCK to further characterize this type of teacher knowledge. Curricular knowledge is the third component of Grossman's model. This component includes knowledge of available curriculum materials as well as knowledge of the vertical curriculum, or the topics that are traditionally taught before an after what the teacher is teaching. The final component of the model is knowledge of instructional strategies. Included in this is knowledge of "metaphors, experiments, activities or explanations that are particularly effective for teaching a particular topic" (p. 9).

2.2.3.4 Ball and Colleagues' Mathematical Knowledge for Teaching

The work of Deborah Ball and her colleagues also builds on Shulman's framework of teacher knowledge. Hill, Ball, and Schilling (2008) describe the knowledge needed for teaching as *mathematical knowledge for teaching* which they define as "the mathematical knowledge that teachers use in classrooms to produce instruction and student growth" (p. 374). Like Shulman (1986, 1987) and Grossman's (2000) characterizations of teacher knowledge, mathematical knowledge for teaching is comprised of differing types of knowledge that represent both subject matter knowledge and pedagogical content knowledge (Figure 2).



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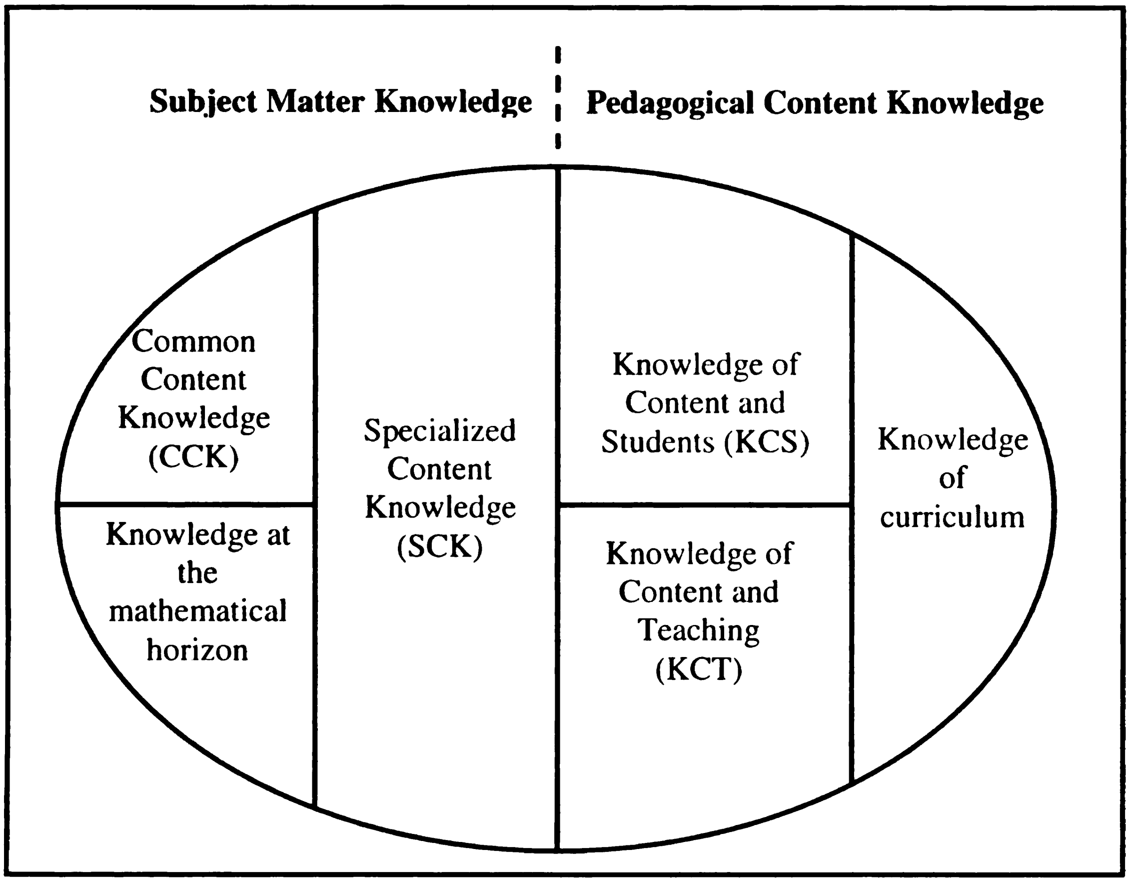

Figure 2. Representation of Hill, Ball, and Schilling (2008) Model of Mathematical Knowledge for Teaching

The type of knowledge in this model that is of particular importance to the proposed study is *knowledge of content and students* (KCS) which is defined as "content knowledge intertwined with knowledge of how students think about, know, or learn particular content" (p. 375). KCS incorporates elements of Schulman's PCK and Grossman's knowledge of students understanding but also includes knowledge of content. This addition is important to the formulation of knowledge being examined in this study because one way that teachers consider how students will interact with the mathematics is to interact with the mathematics themselves. Teachers' knowledge of the mathematics, both at the level at which students engage with it and at higher levels of understanding, contributes to their ability to consider how students will respond to the mathematics as they

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mathematics as they plan lessons. Through the development and testing of measures Hill, Ball, and Schilling have found that KCS is a type of knowledge held by teachers. "The factor analysis of multiple forms and interviews with teachers suggest that familiarity with aspects of students' mathematical thinking, such as common student errors, is one element of knowledge for teaching" (p. 395).

A second type of knowledge that will be important for this study is *specialized content knowledge* (SCK). Ball, Thames, and Phelps (2008) define SCK as:

> knowledge not typically needed for purposes other than teaching…This work involves an uncanny kind of unpacking of mathematics that is not needed—or even desirable—in settings other than teaching. Many of the everyday tasks of teaching are distinctive to this special work. (p. 400)

Although SCK is defined by Ball and colleagues as subject matter knowledge rather than pedagogical content knowledge, it is a type of knowledge that teachers likely use in preparing lesson plans. In preparing lessons plans and making use of SCK, teachers may begin to consider their students' reactions which could lead to making use of KCS. The next section delves further into these ideas by describing the practice of anticipating students' mathematical responses.

2.2.4 Anticipating Students' Mathematical Responses as a Practice of Lesson Planning

Anticipating students' mathematical responses during lesson planning is a practice adopted by some teachers of mathematics that receives its current name from Stein, Engle, Smith, and Hughes (2008). While using this term to describe this particular practice is relatively new to some in the field, the practice itself is not. Leinhardt (1988) described the routines of expert teachers as they related to planning and teaching lessons. In constructing their lesson scripts, or the set of actions they would use to teach a particular topic, exper

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particular topic, expert teachers drew on their knowledge of how students engaged with the mathematics the last time they taught that topic. "Teachers seem to construct flags for themselves that signal material that will cause difficulty as it is being learned, and then they adjust their teaching of the topic in response to those flags or to past successes of what 'worked'" (Leinhardt, 1988, p. 51). Leinhardt also pointed out that novice teachers lack the knowledge of students needed to do this.

> A lesson given by an effective teacher who has been teaching for many years essentially contains layers of accumulated knowledge about the topic and how to teach it...Without these [lesson] scripts novice teachers face two problems. First, they are frequently drawn off their focus to follow a particular student in ways that are not helpful for the rest of the class; and second, they fail to anticipate the crucial feature or dimensions of what is important or difficult about a topic. (p. 52).

Schoenfeld (1998) also addresses a concept that includes anticipating students' mathematical responses, which he describes a lesson image. A lesson image is:

> the teacher's envisioning of the possibilities and contingencies of a lesson. The teacher's lesson image includes knowledge of his or her students and how they may react to parts of the planned lesson; it includes a sense of what students are likely to be confused about, and how the teacher might deal with that confusion; and more. (p. 18)

Schoenfeld goes on to present an example of a lesson image from a teacher named Nelson. The excerpt of the lesson image provided picks up after Nelson has explained that his students will have little trouble with problems (a) and (b).

> In contrast, Nelson expected some initial student confusion with problem (c). He planned to begin as with problems (a) and (b), soliciting student answers. There would, he thought, be some different answers, and some students who said that didn't know or understand. To deal with the confusion Nelson planned to work through the example at the board, expanding $\frac{x^5}{x^5}$ as $\frac{x \cdot x \cdot x \cdot x \cdot x}{x \cdot x \cdot x \cdot x \cdot x}$, canceling the x's, and obtaining $x^0 = 1$ as a result. (p. 40)

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Finally, in her book that describes how she has used problems to teach mathematics, Lampert (2001) provides an example of how she anticipates students' mathematical responses (SMRs) while planning a lesson around the relationship between multiplication and division. She began by considering the different strategies that fifth graders might use to solve the problem she will pose.

> With this work, I was anticipating where my students might get stuck or distracted as well as what might provoke productive work. I needed to think of all the things they would or could do when presented with the problem. This kind of preparation showed me what words might be useful in talking about their solutions, as well as what drawings they or I might use to support their studies. To respond to their work in a thoughtful way, I needed to be able to anticipate what they might be able to do independently and where they would need information from me to proceed productively. (p. 103)

Leinhardt (1988), Shoenfeld (1998), and Lampert (2001) provide evidence that anticipating SMRs is an explicit practice of some mathematics teachers. The next sections further describe this practice by detailing a framework for teachers that includes anticipating SMRs and discussing two widely-used professional development models that make use of the practice.

2.2.4.1 Anticipating Students Mathematical Responses as Part of a Model for Facilitating Mathematical Discussion

Anticipating students' mathematical responses is the first practice in a five-practice model for planning and facilitating mathematical discussion developed by Stein, Engle, Smith, and Hughes (2008). Although the authors do not define what they mean by a practice in this model, their use of the term resonates with Greeno's (1998) definition of *practices* as "regular patterns of activity in a community, in which individuals participate" (p. 6). The model was developed to guide mathematics teachers in their role as discussion facil

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as discussion facilitator; a role which is critical in reform-oriented visions of mathematics teaching. To provide the rationale for such a model Stein et al. begin by describing their view of the reform movement in mathematics education. The "first generation" (p. 316) of this movement brought with it a new vision of mathematics classrooms. In these classrooms students engaged with realistic and complex mathematical tasks and made sense of the mathematical ideas through their own work with the tasks and class discussion. Stein et al. point out that in this generation of reform the role of the teacher in helping students make sense of mathematics through class discussion was "ill-defined" (p. 316). The result was mathematics classrooms in which discussions were often more of a "show and tell" (p. 318) of mathematical solutions than a site for building meaningful mathematical ideas. In response to the lack of direction for teachers the, "second generation" (p. 319) of reform in mathematics came about. This generation of reform "re-asserts the critical role of the teacher in guiding the mathematical discussions" (p. 320) by attempting to identify teacher practices that would support the types of discussions being advocated for in the first generation. Stein et al. address this goal by presenting five key practices for facilitating mathematical discussion based on recommendations from the mathematics education literature that "can make student-centered approaches to mathematics instruction more accessible and manageable for more teachers" (p. 334). The authors suggest that these practices are especially suited to teachers who are new to the idea of facilitating mathematical discussions. "We argue that novices need a set of practices they can routinely do to both prepare them to facilitate discussions and help them gradually and reliably learn how to become better discussion facilitators over time" (p. 321).

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The five practices from Stein et al. (2008) presented in this section are meant to aid teachers in the process of planning and implementing strategies to facilitate mathematical discussion in their classrooms. While only the first practice is the focus of this study, descriptions of the other practices are also provided to help provide context. The first of the five practices calls on teachers to anticipate students' mathematical responses (SMRs).

> Anticipating students' responses involves developing considered expectations about how students might mathematically interpret a problem, the array of strategies—both correct and incorrect—they might use to tackle it, and how those strategies and interpretations might relate to the mathematical concepts, representations, procedures, and practices that the teacher would like his or her students to learn (Lampert, 2001; Schoenfeld, 1998; Yoshida, 1999, cited in Stigler & Hiebert, 1999). (p. 322-323)

As a part of the lesson planning process, anticipating student responses would come after the selection of a mathematically appropriate and cognitively demanding task. Stein et al. present a variety of methods teachers could use to anticipate students mathematical responses:

- Completing the task themselves and considering a variety of possible solution strategies from the perspective of the students in their classrooms
- Working with other teachers to consider possible anticipated SMRs
- Drawing on knowledge from the research literature
- Using curricula that provide possible SMRs
- Watching or reading video and written cases of other teachers teaching with similar tasks

The methods, or sources, of anticipation suggested by Stein et al. are generally available to teachers. Because anticipation is not necessarily based on teaching experiences, the practice of anticipati

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The second practice recommended by Stein et al. (2008) is monitoring students' responses. Teachers can do this while students are working on the mathematical task by walking around and observing the different solution strategies and student thinking. The authors explain that this practice encompasses more than just circulating to keep students on task; the teacher who is monitoring students' responses needs to "actively attend to the mathematics within what the students are saying and doing, assess the mathematical validity of students' ideas, and make sense of students' mathematical thinking even when something is amiss (Nelson, 2001; Shifter, 2001)." (p. 326). Further, they go on to point out that anticipating SMRs, the first practice in the model, supports the practice of monitoring. "Those teachers who have made a good faith effort during initial planning to anticipate how students might respond to a problem will feel better prepared to monitor what students actually do during the explore phase (Lampert, 2001; Schoenfeld, 1998)" (p. 326).

The third practice in the Stein et al. (2008) model is purposefully selecting student responses for public display. It is during this phase that teachers plan what solutions and ideas they want to highlight in the upcoming discussion. This practice allows the teacher to ensure that the desired mathematical ideas and representations are presented and discussed, that misconceptions are put forth and resolved and that ideas not considered by any of the students in the class are brought forward. As with monitoring, anticipating SMRs is helpful for teachers to later select students' responses to make public.

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Like the previous three, the fourth practice, purposefully sequencing student responses, builds on the others. Stein et al. (2008) explain the value of this practice for mathematical discussions, "by making purposeful choices about the order in which students' work is shared, teachers can maximize the chances that their mathematical goals for the discussion will be achieved" (p. 329). The authors provide several possible ways of sequencing student responses including presenting the strategy used by most students first or beginning with a common misconception. They stress the fact that there is no best order but that teachers should consider their knowledge of students and their goals when deciding how to sequence the presentation of student responses.

The final practice for teachers facilitating mathematical discussions in the Stein et al. (2008) model is connecting students' responses.

> They can help students make judgments about the consequences of different approaches for the range of problems that can be solved, one's likely accuracy and efficiency in solving them, and the kinds of mathematical patterns that can be most easily discerned. They also can help students see how the same powerful idea (e.g., there is a multiplicative relationship between quantities in a ratio) can be embedded in two strategies that on first glance look quite dissimilar...So, rather than having mathematical discussions consist of separate presentations of different ways to solve a particular problem, the goal is to have student presentations build on each other to develop powerful mathematical ideas. (p. 330)

This final practice is the last step towards creating the kind of mathematical discussion set forth by the authors at the outset of the article, specifically one in which teachers "orchestrate whole-class discussions that use students' responses to instructional tasks in ways that advances the mathematical learning of the whole class" (p. 314).

As already stated, the practices advocated by Stein et al. (2008) are not new to mathematics educators; they have just been put together in a novel way in a model that is approachable and accessible to experienced teachers thinking about teaching mathematics in a new way and

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in a new way and to preservice teachers just beginning to think about how they will teach mathematics. The practice of anticipating SMRs is also part of two other professional development activities taking place in the United States and other countries. The Cognitively Guided Instruction (CGI) model of professional development has been used in the United States to help elementary teachers make use of their student thinking in their teaching. The tradition of lesson study has been used in Japan, and is enjoying increasing popularity in the United States, as a way to help teachers study their own practices. The following sections outline CGI and lesson study and explain how anticipating SMRs is an integral part of each.

2.2.4.2 Cognitively Guided Instruction

Cognitively Guided Instruction (CGI) employs a specific strategy of anticipating SMRs presented by Stein et al. (2008), namely drawing on knowledge from the research literature. CGI is a professional development program for elementary mathematics teachers based on the tenets that "1) Instruction must be based on what each learner knows, 2) Instruction should take into consideration how children's mathematical ideas develop naturally, and 3) Children must be mentally active as they learn mathematics" (Fennema, Carpenter, & Peterson, n.d., p. 15) In working with teachers the CGI program addresses these tenets by focusing on the development of student's mathematical thinking and building on the teachers existing knowledge (Carpenter, Fennema, Franke, Levi, & Empson, 2000), using research on student's thinking in particular content areas.

An example of the kind of research on student thinking CGI uses in professional development can be found in Carpenter, Fennema and Franke (1996). The authors provide a variety o

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provide a variety of research including some about classes of addition and subtraction problems which they characterize as involving "(a) joining actions, (b) separating actions, (c) part-part-whole relations, and (d) comparison situations" (p. 6). Carpenter, Fennema and Franke explain that their analysis "provides a coherent, principled framework for teachers to understand children's development of basic whole-number concepts" (p. 13). Knowledge of this kind of framework contributes directly to teachers' ability to anticipate SMRs: "The CGI framework also provides teachers a coherent basis for identifying what is difficult and was is easy for students and for dealing with common errors they make" (p. 14). The knowledge of student learning that teachers in the CGI program have access to allows them to anticipate students' mathematical responses by providing them a research base to make the "considered expectations" to which Stein et al. (2008) refer.

Research focusing on the outcomes of CGI has identified positive results for both teachers and their students. In their study of 20 elementary teachers enrolled in a summer CGI workshop, Carpenter, Fennema, Peterson, Chiang, and Loef (1989) found that once they returned to their classrooms:

> CGI teachers more often posed problems to students and more frequently listened to the process used by students to solve problems. In contrast, in giving feedback on students' solutions to problems, control teachers focused more frequently on the answer to the problem than did the CGI teachers. (p. 520)

In addition, there was a slight difference in student achievement between the students in the classes of the CGI teachers and those in the classes of the control teachers. "Although differences in student achievement were modest, the differences found consistently favored the CGI treatment group" (p. 526).

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2.2.4.3 Lesson Study

The Japanese practice of lesson study differs as a professional development program from CGI in that it does not provide information that will help a teacher anticipate SMRs in the way that Stein et al. (2008) describe. Instead, lesson study expects that teachers will anticipate SMRs and provides a lesson framework and community that supports teachers in doing this. Lesson study holds a prominent position in the professional development of Japanese teachers and dates back to the early 1900s (Fernandez, 2002; Shimuzu, 2002). "Lesson study brings together groups of teachers to discuss lessons that they have first jointly planned in great detail and then observed as they unfold in actual classrooms" (Fernandez, 2002, p. 393). Although the practice originated in Japan, U.S. teachers have recently taken up the practice for their own professional development (Chokshi & Fernandez, 2004). The structure of lesson study incorporates several features that support teachers in anticipating SMRs.

> They begin the process ...by reading about what other teachers have done, what ideas are recommended by various educational groups, what has been reported on students' learning of this topic, and so on. They design several lessons, one group member tries them out while the others observe and evaluate what works and what does not, and they revise the lessons. They often base changes on specific misunderstandings students' evidence as the lesson progresses. (Hiebert & Stigler, 2000, p. 10)

In addition to taking these steps which are intended to produce increasingly better lessons, the written lesson plans themselves include what the teachers anticipate that students will respond. Shimizu (2002) presents the following as a common framework for lesson plans that are designed in the lesson study process (Figure 3).

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Steps	Main Learning Activities	Anticipated Students' Responses	Remarks on Teaching
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Whole-class discussion			
Summing up			
(Exercise/Extension)			

Figure 3. Shimizu's (2002) Common Framework for Lesson Plans

Notice that the anticipated SMRs are thought out for each phase of the lesson and are considered before the planned actions of the teacher.

To get a clear picture of what anticipating SMRs might look like in a written lesson plan, Shen, Poppink, Coi, and Fen (2007) provide an example. Although they present a lesson from a Chinese teacher and not Japanese teacher involved in lesson study, the Chinese lesson has many of the same components as the Japanese lesson study lesson plans and can still serve as an example for those unfamiliar with the practice of anticipating in a written lesson plan. Shen et al. present steps that are common to the Chinese teachers' lesson planning process "(a) specifying cognitive and affective objectives; (b) identifying key points of the content; (c) anticipating difficult points for students; and (d) designing the lesson flow" (p. 251). As in Japan, Chinese teachers use lesson planning as more than just a list of activities to complete in class, instead they view it as "a practice of professional responsibility and development" (p. 248).

The lesson plan presented by Shen et al. (2007) was designed to allow students to explore the sum of measures of internal angles of a polygon. In anticipating SMRs the teacher identifies

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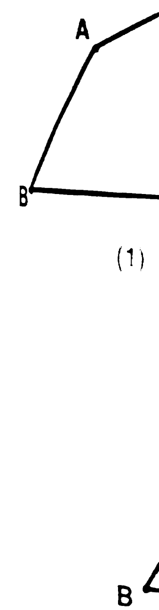

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teacher identifies a possible difficulty students might encounter: "*Difficult point: a student's understanding that the vertices of a polygon must be on the same plane, a necessary condition that is difficult for many students to understand*" (p. 252). Also included in the plan are a variety of possible student strategies (Figure 4).

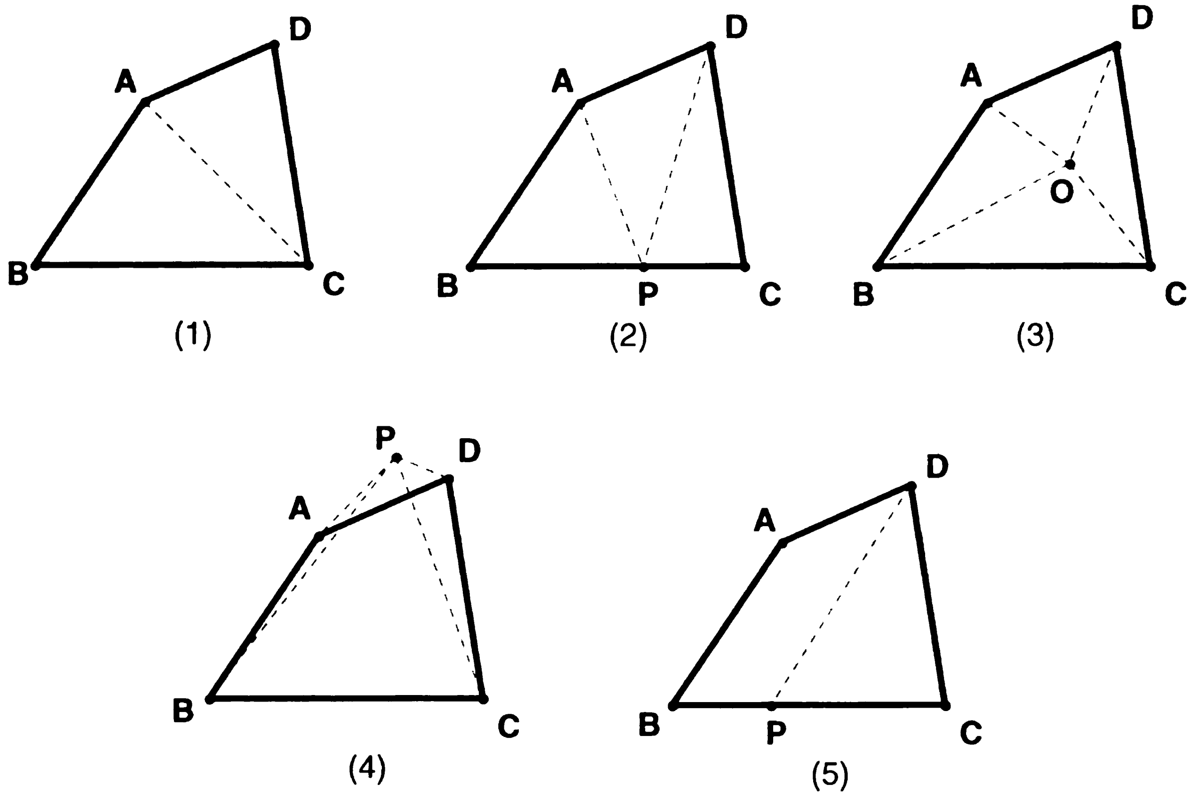

Figure 4. Representation of Possible Strategies Identified by the Teacher That Students Might Employ to Find the Interior Angle Sum of a Quadrilateral (Shen et al., 2007)

This lesson plan considers two of the main aspects of anticipating SMRs outline by Stein et al. (2008), namely student solution strategies and common student difficulties.

The next section presents the research questions for the study and outlines the framework created by the researcher for use in this study. This framework is based on the situative perspective and the literature reviewed here about teacher knowledge and the practice of anticipating.

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2.3 Research Questions and Framework

This study made use of the situative perspective to investigate a field experience by describing the situations and communities that made up the field experience and by "working inward" as described by Greeno (1998) to look at the practices of one SMPT as she participated in these situations and communities. During field experiences preservice teachers are influenced by a variety of contextual factors including university courses, mentor teachers, field instructors, school communities, students, available resources, and possibly unknown factors. The focus of the situative perspective on environmental contexts, social interactions, and tools necessitated that the researcher take into account these contextual factors. Additionally, the researcher was able to focus on a more cognitive aspect; that is, one preservice teacher and her developing lesson planning practices.

To narrow the scope of the study within the field experience, this study focused on a specific lesson planning practice, namely anticipating students' mathematical responses. A *practice* is defined here as Greeno (1998) defines it as "regular patterns of activity in a community, in which individuals participate" (p. 6). This practice was selected as the focus of this study for three reasons. First, research has shown that the practice of anticipating students' mathematical responses relies on a type of knowledge that preservice teachers often do not have access to when they enter field experiences. Second, anticipating students' mathematical responses represents a practice not yet studied in relation to SMPTs. Third, this practice was a key practice advocated by the secondary mathematics teacher preparation program at the university where this study took place. Fo

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took place. For this study, the practice of anticipating students' mathematical responses will be defined as considering how students will react to the lesson, specifically the mathematics and the mathematical tasks, as the lesson is being planned or any time prior to the teaching of the lesson. This practice encompasses other practices of teaching that are described in relation to the upcoming anticipation framework.

Using this definition of anticipating students' mathematical responses and the situative perspective to examine both the context of the experience and to narrow in on the experience of one preservice teacher, the study addressed the following research questions:

1. What is the nature of a preservice teacher's practice of anticipating students' mathematical responses during lesson planning over the first semester of her field experience?
2. What factors within the contexts of a teaching internship (a field experience and accompanying university course) promote or do not promote the practices of one preservice teacher anticipating students' mathematical responses during lesson planning?

The research framework employed in this study was developed based on the previously reviewed literature and the situative perspective. Figure 5 shows the anticipation framework developed for this study.

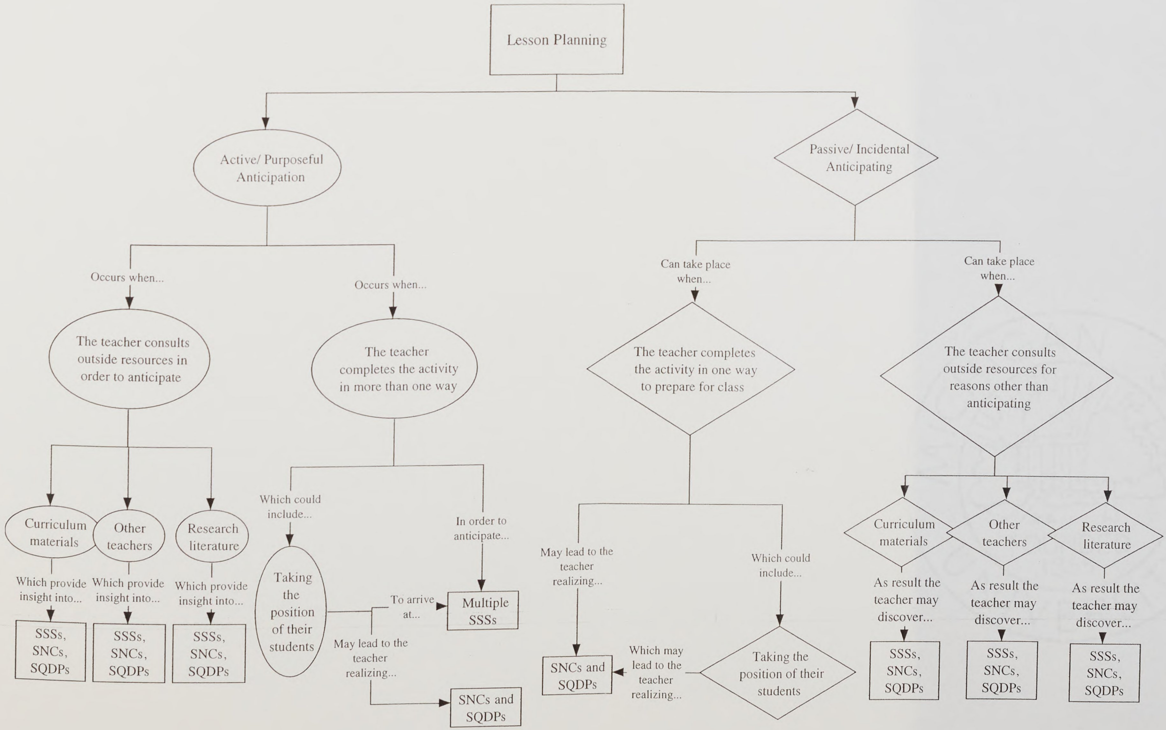

Figure 5. Anticipation Framework

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The anticipation framework is divided into active/purposeful and passive/incidental components, both of which have the potential to lead to three types of outcomes: student solution strategies (SSS), student naïve conceptions (SNC), or student questions and difficult points (SQDP). These outcome categories were based on the literature that showed that as teachers plan mathematics lessons they anticipate several types of student responses. First, teachers anticipate students' solution strategies by considering various ways that students could solve problems and approach tasks (Lampert, 2001; Shen, Poppink, Cui, & Fan, 2007; Stein, Engle, Smith, & Hughes, 2008). Second, teachers are mindful of the naïve conceptions or misconceptions that students bring with them to class which will have an impact on how they interact with the lesson (Carpenter, Fennema, & Franke, 1996; Stein, Engle, Smith, & Hughes, 2008). Third, teachers identify points in the lesson that may be difficult for students and where they may need extra help to successfully participate in the lesson (Carpenter, Fennema, & Franke, 1996; Gaea Leinhardt, 1988; Schoenfeld, 1998; Shen, Poppink, Cui, & Fan, 2007).

The active/purposeful side of the framework represents the actions taken when a teacher chooses to anticipate students' mathematical responses (SMRs) as described by Stein et al. (2008). In other words the teacher "makes an effort to actively envision how students might mathematically approach the instructional tasks(s) that they will be asked to work on" (p. 322). After a teacher has made the choice to anticipate SMRs during lesson planning they can choose to participate in one or more activities that would help them to do this. Two of the three outside resources listed on the left side of the framework were suggested by Stein and colleagues. An additional resource, other

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teachers, was added to this side of the framework based on the situative perspective, specifically the focus on the distributed nature of knowledge. When the teacher consults these resources, attempts to complete the task in multiple ways, or takes the position of students they are drawing on either their own knowledge of content and students (KCS) or the KCS that is distributed in the mathematics education community.

The passive/incidental side of the anticipation framework is made up of the same resources and activities that appear on the active/purposeful side of the framework. The difference is that the right side of the framework represents participation in these activities or use of these resources for reasons other than the anticipation of SMRs. All of these resources and activities have purposes in teaching other than anticipation. Despite the originally intended purpose, participation in these activities or use of these resources might contribute to a teacher anticipating SMRs if they come across this knowledge and choose to make use of it. One difference between the elements on the active/purposeful side and the elements on the passive/incidental side is that when the teacher completes the activity in one way to prepare for class they are likely not making use of KCS. KCS includes knowledge of how students respond to particular content, but in this case the teacher is preparing one strategy to present to students. In this instance the teacher is likely drawing on their own *specialized content knowledge* (SCK) to prepare one solution method for the lesson that is based on their own way of looking at the mathematics.

In addition to the anticipation practices, resources, and outcomes, the anticipation framework also takes into account the influence of the situated nature of the experience. The Zone of Free Movement (ZFM) is represented by the resources that appear in the framework. For example, if the teacher does not have access to research literature they will not have th

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will not have the ability to use it to anticipate or for any other reason. The Zone of Promoted Action (ZPA) has bearing on which path through the framework a teacher chooses to take.

In addition to the anticipation framework, this study makes use of a combination of Goos' (2005a, b) framework and Engle and Conant's (2002) principles of productive disciplinary engagement. In this part of the research framework for this study, the ZFM and the ZPA are each composed of two of the principles:

Zone of Free Movement

- Relevant Resources
- Authority

Zone of Promoted Action

- Problematizing Content
- Accountability to Others and Disciplinary Norms

In Goos' framework the ZFM represents what is possible, which in her characterization includes teaching resources and curriculum and assessment requirements. Thus, in this study the ZFM represents the resources available to support the practice of anticipating and the use of authority that allows for the practice of anticipating. The ZPA represents the actions of the university or school faculty to promote particular practices. In this study the ZPA is comprised of the actions or elements of the contexts that problematize teaching and/or mathematics in ways that lead, or do no lead, to the practice of anticipating and the norms that the intern is held accountable to that promote or do not promote anticipating. The next chapter details how the methodology of this study, including how the anticipation framework was used for data analysis.

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CHAPTER 3. METHOD

This study examined how one secondary mathematics preservice teacher anticipated students' mathematics responses in her lesson planning during the first semester of her internship year. This chapter outlines the methods, data sources, and analytic techniques used in this investigation.

The process of inquiry used in this project was primarily case study. In case studies, researchers explore "in depth a program, an event, an activity, a process of one or more individuals" (Stake, 1995 as cited in Creswell, 2003, p. 15). Further, case studies are defined by "interest in individual cases, not by the methods of inquiry used" (Stake, 2000, p. 435). They are "bounded by time and activity, and researchers collect detailed information using a variety of data collection procedures over a sustained period of time" (Stake, 1995, cited in Creswell, 2003, p. 15). This study's design met these criteria in that it focused on one individual, Megan, and her practices and interactions during the first semester of her field experience and used a variety of data to build the case study.

Another process of inquiry present in this study was ethnography. In ethnography, researchers study "an intact cultural group in a natural setting over a prolonged period of time by collecting, primarily, observational data" (Creswell, 2003, p. 14) with an intent to "obtain a holistic picture of the subject of study with emphasis on portraying the everyday experiences of individuals by observing and interviewing them and relevant others (Creswell, 2003, p. 200). By studying Megan's interactions in both of the contexts of her field experience, as she planned lessons and worked, this study has made use of ethnographic methods. The researcher in this study was a teaching assistant in one of the courses taken by Megan and her peers prior to the study and continued to serve as a resource and source

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3.1. Context

The two main contexts in which the preservice teacher, Megan[4], operated were sites for analysis in this study. The following two sections describe each of these contexts.

3.1.1 University Context

The university context was set in the mathematics teacher education program in a large Midwestern university. Prospective teachers in this program spend five years at the university. All prospective teachers graduate with a mathematics degree after four years and obtain a teaching license after their fifth year of structured field experience, referred to as the internship year. In addition to the education coursework required of all prospective teachers seeking licensure at the university, secondary mathematics preservice teachers enroll in four mathematics-specific methods courses in their fourth and fifth years of study. The first set of courses will be referred to as the senior year

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[4] In order to protect anonymity all names are pseudonyms.

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methods courses and the second set, which take place during the internship year, simply as the methods courses.

The university's internship program is designed as a year-long experience in the fifth year of the teacher preparation program. During the semester that data was collected, the program elements remained consistent with what they had been in previous years and all portions took place as expected. The interns spent the entire school year in a school teaching mathematics classes alongside their mentor teacher. Figure 6 shows the intended schedule of the teaching load and university courses, both general and content specific, as described in the teacher education program handbook.

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Figure 6.

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5 Extra prep hour											
4											
3											
2											
1 Focus Class											
Field (estimated duration)	5-6 Weeks	**Lead 1** 2 weeks	3 weeks	**Lead 2** 2 weeks	4-5 weeks		2-3 weeks	**Lead Teaching 3** 10 weeks		4 weeks	
Seminar	General Seminar and Methods Course						General Seminar and Methods Course				
(duration)	5 weeks	2 weeks	3 weeks	3 weeks	2 weeks	1 week	5 weeks	4 weeks	3 weeks	2 weeks	2 weeks

Figure 6. Schedule of Intern Teaching Responsibilities

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The experience is designed so that the interns take full responsibility for one class, called the Focus Class, beginning the first week of the school year and continuing until the end of the field experience. During the first semester the intern is to have primary responsibility for one additional class during Lead 1 and two additional classes during Lead 2. The secondary teacher preparation program handbook provides specific guidance on the expectations of the interns' development of lesson planning practices within the internship experience.

> In lesson planning, the intern learns to design purposeful and practical activities that carry a unit forward. She or he learns to anticipate and adapt to situations that might arise in those activities, to use time efficiently, and to allow for the unexpected. Again, the Mentor Teacher and field instructor offer support, feedback and coaching. (Handbook, p. 14)

In addition to teaching in a school during the internship year, the interns continued to attend classes at the university one day a week for ten weeks of the 15 weeks of the semester. During the first semester the university courses did not meet during the Lead 1 and Lead 2 weeks. On the days that the interns returned to the university they participated in two courses, one general education course focusing on professional roles and teaching practices and the other, the methods course, which was specifically related to reflection and inquiry in secondary mathematics teaching. The next sections describe the senior year and internship methods courses.

3.1.1.1 The Senior Year Methods Courses

During their fourth year in the program the secondary mathematics preservice teachers enrolled in two methods courses, one during the fall semester and one during the spring semester. Although most of the preservice teachers completed a bachelor's degree in mathematics by

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in mathematics by the end of their fourth year, the senior year methods courses were the first classes they took in the college of education related specifically to the teaching of mathematics. An important aspect of the design of the senior year methods courses was the field component. The preservice teachers were required to spend four hours per week in a local middle or high school mathematics class and to teach several lessons each semester. Many of the course assignments and discussions in the senior year methods courses were based on the preservice teachers' experiences in this field experience. Another key component of the fall section of the senior year methods course was the microteaching lab, in which the preservice teachers collaboratively wrote and individually taught two to three lessons to their peers and received feedback from peers and instructors.

The goals of the senior year methods courses as stated in the syllabi were that preservice teachers would:

- Deepen and connect mathematical content knowledge with student mathematical understanding.
- Develop a deeper understanding of the mathematics content you are teaching and how it can be meaningful for your students.
- Analyze from a new perspective what mathematics is and what it means to learn, do, and teach mathematics.
- Learn to listen to and look at students' work as a way to inform teaching, using evidence from these to make decisions.
- Learn to design and implement lessons in ways that engage students in learning (tasks, sequence, discourse, questioning, use of technology)
- Learn to reflect on your practice – both from your perspective as a teacher, as a researcher, as a learner, and from the perspective of what you see students learn.
- Recognize what is meant by equity and access to quality mathematics for students, parents and communities (including attention to policy)
- Develop an understanding of what it means to have high expectations for all students.

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- Develop strategies and frameworks for planning and assessment.
- Develop mathematics teaching strategies, such as lectures and class discussions, cooperative groups, activities, etc.
- Learn about mathematics support systems, including state and national standards, texts and other teaching materials, mathematics teacher organizations and conferences, etc.
- Develop knowledge of techniques of assessing students' understanding.

The senior year methods courses played an important role in this study because they were the settings in which Megan and the other preservice teachers were first introduced to the practice of anticipating students' mathematical responses (SMRs). Anticipating SMRs was defined for the preservice teachers as thinking about the lesson from the perspectives of the students. To do this they were asked to consider the various strategies students might use to engage in the lesson activity, what problems or misconceptions might arise, and what kinds of questions the students might ask. The preservice teachers were directed to resources to help them anticipate SMRs, such as curricula available in the methods course classroom that provided multiple solution strategies, articles in teacher journals, and their mentor teachers in their field placements. In addition, preservice teachers were encouraged to solve the mathematical tasks in a variety of ways on their own and to consult with the instructors of the course and other interns for ideas. The preservice teachers were expected to make use of the recommendations to carry out this practice in three different assignments: (1) researching misconceptions in the National Council of Teachers of Mathematics (NCTM) teaching journals as part of the microteaching lab, (2) anticipating solution strategies, questions, and possible misconceptions twice during each semester when they lead the discussion around a mathematics homework problem, and (3) in writing lesson plans for their field experience. Preserv

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experience. Preservice teachers were further exposed to the practice of anticipating SMRs during a mathematics education colloquium at the university with Dr. Margaret Smith, who advocated it as a practice helpful for facilitating mathematical discussions.

The first assignment requiring the preservice teachers to anticipate SMRs took place in the microteaching lab. As part of the fall section of the senior year methods course the preservice teachers participated in a weekly microteaching lab in which they prepared lesson plans on a given content topic and taught the lesson to their peers. Two times during the fall semester preservice teachers who were not teaching in a particular week were called upon to research a common student misconception related to the topic being taught that week. The preservice teachers were directed to research these misconceptions in the NCTM teaching journals, although many also used other resources including the internet and the curricular materials from their field placements. After the preservice teachers researched the misconceptions they wrote a brief summary of their findings and brought them to class. The final part of the misconception assignment was to find a way to pose a question or solve a task that reflected this misconception. Although this assignment did not broadly call on preservice teachers to anticipate SMRs it was designed to introduce them to the possible misconceptions associated with specific content and to begin to build the practice of consulting professional teaching journals for information about how students might engage with particular mathematics.

The second assignment in which the preservice teachers were asked to anticipate SMRs was in facilitating discussions of the weekly mathematics homework problems. This assignment ran through both semesters of the senior year methods courses. Each week all of the preservice teachers in the course completed a mathematics problem as homework and brou

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homework and brought their solutions to class. Two preservice teachers were assigned to lead a discussion around their classmates' solutions and then discuss potential naïve conceptions (referred to as misconceptions during the class) that might arise if middle or high school students were attempting to solve the problem. A written description of this assignment can be found in Appendix A. The preservice teachers were supported in considering the possible SMRs in required meetings with instructors that took place before the class. In these meetings the SMRs that the preservice teachers had thought of prior to the meeting were discussed. In addition, the preservice teachers were prompted to consider other SMRs through questioning by the instructors and in some cases the instructors shared mathematical responses that had come up in their own experiences using the problems or those like them.

The third assignment that asked the preservice teachers to anticipate SMRs in the senior year methods course was the lesson plan assignments. During the course of the year the preservice teachers were asked to write many lesson plans, some for the field component to teach, some to teach for the microteaching lab, and some for other course assignments including a lesson study project. The lesson planning format that the preservice teachers were asked to use can be found in Appendix B. For each lesson plan the preservice teachers were asked to anticipate student thinking and questions. Each lesson plan went through several revisions based on instructor feedback and the preservice teachers' reflections after teaching the lesson.

Finally, the preservice teachers were re-introduced to the idea of anticipating SMRs in a colloquium that they attended late in the fall semester. Dr. Margaret Smith, one of the authors of the article about the five practices for orchestrating mathematical discussions present

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discussions presented in Chapter 2, spoke to the mathematics education community at the university, including the preservice teachers enrolled in the senior year methods course. Dr. Smith discussed the five practices during her talk and gave examples of how teachers could prepare to do each practice in their own classrooms. A debrief with the preservice teachers after the colloquium revealed that they recognized anticipating SMRs as an idea that the instructors had been advocating. Many of the preservice teachers agreed that they had a better idea of what it meant to anticipate SMRs, how to do it, and why it was important from listening to Dr. Smith. The next sections describe the internship year methods course and the school context.

3.1.1.2 The Internship Year Methods Course

In the internship year the preservice teachers, henceforth referred to as interns, participated in two classes related specifically to the teaching of mathematics, one during the fall semester and one during the spring semester. The spring section of the internship year methods course is beyond the scope of this study and will therefore not be described here. The fall section of the methods course continued the emphasis of many of the practices introduced in the senior year methods courses, including anticipating SMRs, and in addition engaged the interns in structured inquiry about the teaching and learning of mathematics. The activities of the fall semester of the methods course are detailed in Chapter 4.

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3.1.2 The School Context: Logan High School

Megan participated in the teaching portion of the internship experience at Logan High School[5]. Logan is a village located approximately 65 miles southeast of the university. Megan attended and taught at this school four or five days a week for the entire 2008-2009 academic year. The responsibility for teaching the mentor teacher's classes built gradually over the course of the first semester, as explained in a previous section. Megan and her mentor teacher, Mrs. Starns, chose an Algebra 2 class as Megan's Focus Class. Data for this study was gathered primarily from the Focus Class, and in some cases from additional sections of the same course when Megan was teaching. The school, the mentor teacher, and the Focus Class are further described in Chapter 4. The next sections describe the participants of the study.

3.2 Participants

The main participant of the study was a preservice teacher named Megan. Megan was several years older than many of the other interns due to the fact that she had changed her major to mathematics after spending her first two years at the university in fine arts. Within her peer groups Megan appeared to get along with the other interns. In her senior year she was seen as a source of help by her peers for creating engaging ways to begin mathematics lessons. Logan High School was located close to Megan's home district and she lived at home with her parents during the internship year. Megan and her family knew many of the students at the school through social and church relationships.

[5] Pseudonyms are used throughout to protect the anonymity of all participants

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Megan was purposefully selected as the participant of the study, as described by Creswell (2003), because during her senior year methods courses she represented some of the ideal qualities that a teacher educator might identify for a prospective mathematics teacher. First, her participation in the senior year methods course showed her to be interested and engaged in the process of learning to teach mathematics in ways described by the university. Second, her interest in students as learners was observed by her senior year mentor teacher and her enthusiasm for working with students in general was evidenced in her choice to be an assistant basketball coach at a local middle school. Finally, the level of her lesson preparation exceeded that of many of her peers in the methods course. Her lesson plans were much more detailed and often focused on engaging students at the outset of the lesson and finding ways of allowing the mathematics to unfold as opposed to telling the students what they were supposed to learn.

Megan could be termed "ideal" in that she came to the senior year methods courses with enthusiasm for mathematics, teaching, and students and that she embraced the methods and ideas being taught and discussed in the course. Studying the experiences of an "ideal" preservice teacher afforded the opportunity to trace her development into her field experience to see how that field experience impacted her participation in practices of lesson planning, either toward or away from ideas advocated by the university program. Teacher educators may have experiences with preservice teachers who are less engaged or less interested in thinking about new ways of teaching mathematics. Studying these prospective teachers would provide insight into whether or not the internship changed their beliefs about teaching mathematics and what factors prompted that cha

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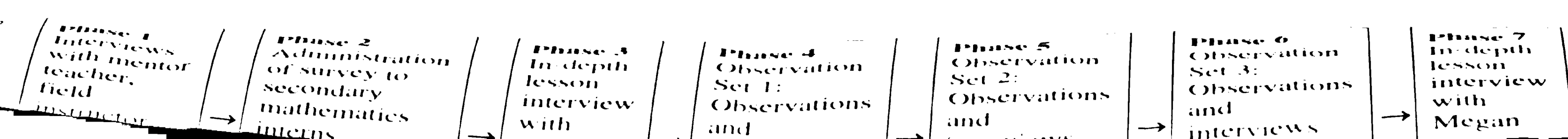
prompted that change. However, this was not the goal of this study. The goal of this study was to detail how one preservice teacher already on the path of participating in practices of lesson planning that focused on students, continued on this journey during her final field experience.

Although the focus of this research was a case study of Megan, additional data was collected from other group participants. These other groups were important to this study because they served as elements of the contexts both in general and in the role of supporting or not supporting the practice of anticipating. The first was the larger group of secondary interns enrolled in Megan's methods course. Of the 17 interns in the course, 16 agreed to be part of this study. The second group was the university instructional team that worked with Megan which was made up of Dr. Rundell, the instructor of the methods course, and Emily, Megan's university field instructor. The final additional participant in this study was Megan's mentor teacher, Mrs. Starns. Even though these groups are not the main focus of this study, their interactions with Megan impacted her participation in practices of mathematics lesson planning. Each participant, or groups of participants, is further described in Chapter 4. The next section describes the data collection process that was used in this study.

3.3 Instruments, Data, and Data Collection

Data collection for this study took place in seven phases with an additional phase of collection that took place throughout the fall semester. Figure 7 summarizes the data collection phases.



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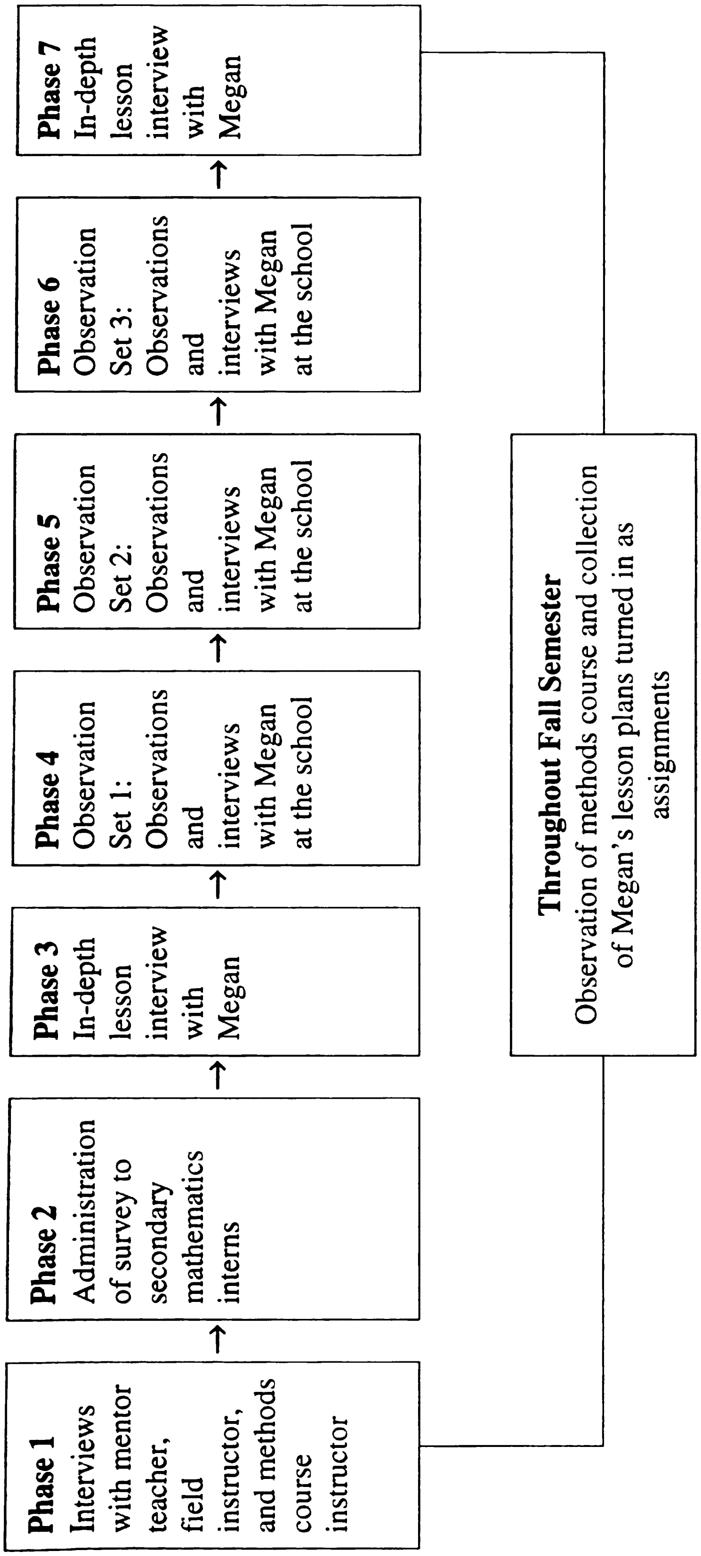

Figure 7. Summary of Data Collection Phases

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The next sections describe the instruments, data collected, and methods used in each of the phases of data collection. For each interview conducted, the interview was audio-recorded and transcribed.

3.3.1 Phase 1. Initial Interviews

Initial interviews were conducted with Megan's mentor teacher, the methods course instructor, and Megan's field instructor. The interview with Megan's mentor teacher, Mrs. Starns, took place in early October near the beginning of Megan's internship. The interview was adapted from an interview used by Mossgrove (2006) to collect similar data about the context of a field experience (see Appendix C for the interview protocol). The interview was designed to elicit response from the mentor teacher to provide context for the field experience school and classroom, specifically in the areas of the school environment, the mentor teacher's expectations of the intern, and her plans for supporting Megan in meeting those expectations.

The interview with Megan's field instructor, Emily, was conducted in mid September (see Appendix D for the interview protocol). The interview was designed to gather data about the expectations and plans of the field instructor for supporting the intern during the fall semester in lesson planning as well as other areas.

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Finally, the interview with the methods instructor, Dr. Rundell, took place in early October (see Appendix E for the interview protocol). The interview was designed to provide context for the methods course by eliciting responses about the goals, expectations, and assignments of the course, as well as information about how the course is related to the field experience and whether the intern teachers have opportunities to collaborate. The interviews with each of these participants resulted in data in the form of three transcripts.

3.3.2 Phase 2. Lesson Planning Survey

The Lesson Planning Survey (LPS) was designed to gather data to from the group of interns to address the second research question regarding the factors of the contexts. The LPS was completed by all 16 of the interns consenting to participate in the study, including Megan (the survey can be found in Appendix F). This aspect of data collection generated 16 completed, written surveys. The survey had two parts. The first part asked the preservice teachers to write a detailed list of what they did during their senior year methods courses to prepare lesson plans. The second part of the survey asked more focused questions about the interns past planning and how they think they will plan differently in the upcoming field experience. Additionally, the survey questions solicited the interns' responses as to why the practice of anticipating is important and finally the interns were asked to anticipate SMRs in a particular content area. The goal of the survey was to gather information in order to (a) describe what the interns perceived to be their past practices in anticipating, specifically those that took place in the senior year methods courses; (b) describe what the interns viewed as the importance and purpose of anticipating; and (

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3.3.3 Phase 3. First In-Depth Interview

The In-Depth Lesson Interview 1 was conducted with Megan in mid September and prior to any school observations (see Appendix G for the interview protocol). The first part of the interview was adapted from an assignment used by Mossgrove (2006) in her study of secondary mathematics preservice teachers' lesson planning practices. The questions in this protocol included all of the questions from the Pre-Lesson Interview Protocol, which is described in the next section, as well as additional questions used by Mossgrove. This part of the interview was designed to provide a much more in-depth examination of Megan's lesson planning process than the daily interviews could due to time limitations. The second part of the interview focused on probing and clarifying Megan's responses to the LPS. The goals of the interview were to (1) gather data about how Megan planned lessons at the beginning of her field experience, including anticipating SMRs, and (2) to probe further into Megan's thinking as revealed through the LPS. Data from this interview consisted of the written lesson plan that Megan brought to the interview and the transcript of the interview.

3.3.4 Phases 4, 5, and 6. Lesson Observations and Interviews

Phases 4, 5, and 6 all consisted of three- to five-day interactions with Megan at her internship school. During these interactions Megan was observed teaching her Focus Class and before and after each of these lessons short interviews were conducted (see Appendix H for the interview protocol). For each lesson observation Megan supplied a copy of her lesson plan for the day along with any supplemental notes she made. A total of 15 Pre- and Post-Interviews took place. Phase 4 included five lessons plus a special Cool Stuff lesson[6]. Phase 5 included five lessons plus a special Cool Stuff lesson. Phase 6 included three lessons. In each phase the Pre-Interviews asked Megan to describe the lesson that she was going to teach and how she planned it, including questions related to her anticipation practices. The Post-Interview asked Megan to reflect on how the lesson went, including anything that surprised her and whether she would make any changes to the lesson for the next day based on what happened during the class. The goal of these interviews was to uncover anything that Megan anticipated that she did not include in her written lesson plan, to elicit her reaction to events that occurred in the class that she did not anticipate, and to see if teaching the class prompted her to anticipate for the next lesson. Data from these interviews consisted of Megan's written lesson plans and the transcripts of the interviews.

3.3.5 Phase 5. Second In-Depth Interview

The final interview was conducted in December at the conclusion of the first semester (Appendix I). As with In-Depth Interview 1, Megan was asked to bring a

[6] The Cool Stuff lessons were lessons prepared for the university and taught in the school. They are further described in Chapter 4.

completed lesson plan that she would use in her teaching and was interviewed around that lesson using the same protocol. In addition, Megan was asked to create a list of what should be included in a lesson plan. The remainder of the semi-structured interview probed what Megan thought she has learned about lesson planning from the first semester of participating in her field experience. The goals of the interview were to (1) have Megan create a list of what belongs in a lesson plan, (2) to inquire into Megan's perceptions of the field experience, and (3) to gather data about how Megan plans lessons at the end of the first semester of her field experience, including anticipating SMRs. Data from this interview consisted of the written lesson plan that Megan brought to the interview and the transcript of the interview.

3.3.6 Throughout Fall Semester

The final portion of data collection took place throughout the fall 2008 semester. All of the methods course meetings were observed and field notes were taken in reference to how lesson planning in general, and anticipating SMRs in particular, was presented and discussed during the class. Casual conversations that took place on the side during classes between the interns were also included in field notes to gather data about the interns' perceptions about the course, the internship experience as a whole, and their lesson planning practices and questions to one another. Finally, during this phase Megan was asked to provide any lesson plans that she turned in as course assignments. The purpose of this phase of data collection was to gather data that will provide insight into the context of the methods course and also into Megan's lesson planning for the course. Data from the class consisted of the course syllabus and assignments, observation field

notes, and on-line exchanges and postings on the course website. The next section details the data analysis methods used in this study.

3.4 Data Analysis

The next sections outline how data was analyzed for this study and are framed by the two research questions. In general, data analysis was framed by Miles and Huberman's (1994) three components of data analysis: (1) data reduction, (2) data display, and (3) conclusion drawing/verification (Figure 8).

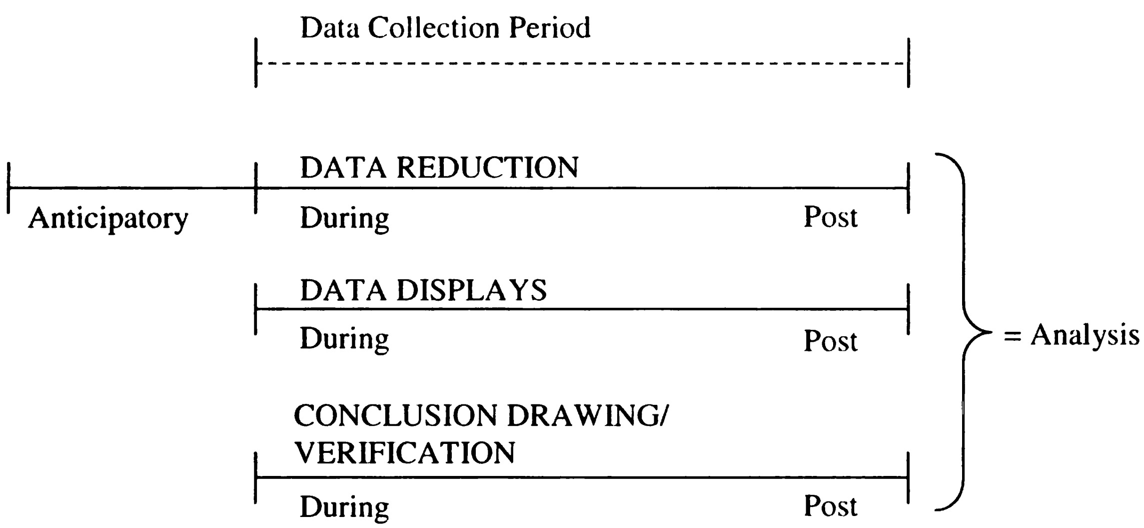

Figure 8. Representation of Miles and Huberman (1994) Components of Data Analysis: Flow Model

The application of each of these components is described in the following sections.

3.4.1 Analysis of Research Question 1: Describing the Practice of Anticipating

Research Question 1: What is the nature of a preservice teacher's practice of anticipating students' mathematical responses during lesson planning over the first semester of her field experience?

In order to answer the first research question Megan's written lesson plans and transcripts of interviews with Megan were analyzed.

3.4.1.1 Research Question 1 Data Reduction

The analysis of data for the first research question was based on two data sources, Megan's written lesson plans and transcripts from lesson interviews (In-Depth Interview 1, In-Depth Interview 2, and Pre- and Post-Lesson Interviews). For this study a lesson was defined by the classroom activities for a single day, which in most cases represented one section from the classroom textbook. The exceptions to this were the two Cool Stuff lessons, each of which served as review lessons, and the lessons in the second set of observations which were reorganized by Megan and Mrs. Starns and thus did not follow the sections or sequence of content laid out by the textbook. Only the lessons in which Megan taught content to the class and the Cool Stuff lessons were included in this part of the analysis. During the first set of lesson observations three days were used for review of homework, two quizzes, and a non-mathematical game and so these lessons were not included in this part of the analysis, though information from the corresponding interviews was used in the analysis for the second research question. In total 11 lessons were analyzed to answer the first research question.

Each written lesson plan was paired with the transcripts of the interview or interviews that accompanied it. In the case of the lesson plan for In-Depth Interview 1 the lesson plan brought to the interview was paired with the transcript for Part 2 of the interview, similarly for the lesson plan for In-Depth Interview 2. Each of the 11 lessons prepared solely for teaching in the school was paired with the Pre-Lesson Interview and Post-Lesson Interview for that day.

The first step in the analysis of the lesson plans and transcripts was the identification of anticipated student mathematical responses (SMRs). For this study instances of anticipating were defined as any prediction, either written or verbal, made by an intern about what students would do during class in response to the lesson. Examples of such predictive statements are "I think that students will have a hard time with…" or "they could solve this in two ways…" Each instance was coded using the following codes: (1) student solution strategy (SSS), (2) student question or difficult point (SQDP), and (3) student naïve conception (SNC). Instances coded with SSS represented any strategy or solution, either correct or incorrect, that the intern anticipated the students would come up with during the lesson or for assigned homework. The SQDP code was assigned to any instance that identified a part of the lesson that might be mathematically difficult for students or questions that students might ask. Finally, The SNC code was used any time the intern identifies possible naïve conceptions that might hinder the learning experience for the students. The interns are most familiar with the word "misconception" and so these instances were often described using that term. Any instance that exemplified more than one of these codes was coded with all appropriate codes.

The second part of the analysis focused on identifying the resources used by Megan in planning the lesson, and when possible linking the resources to what was anticipated. Again using the written lesson plans and interview transcripts, resources and

resource activities that Megan used and participated in were identified. All resources, or resource activities, were coded with one of the following codes:

- The teacher completes the activity in one way
- The teacher completes the activity in more than one way
- Taking the position of students
- Curriculum materials
- Other teachers
- Research literature

These resources were most often identified by Megan herself in the interviews when she was asked how she figured out something that she anticipated or when she explained how she used a resource for another purpose only. After the resource and resource activities were identified they were then further coded as being part of either active/purposeful or passive/incidental anticipating[7]. If Megan made use of a resource, but not for the purpose of anticipation, it was coded as passive/incidental so that resources that were used in general were identified. Some of the anticipated SMRs were indentified as having two sources. As an example, Megan's mentor teacher shared a specific SMR that Megan had also considered from completing the problem herself. In these cases two codes were used.

3.4.1.2 Research Question 1 Data Display

After the data was coded for each lesson an anticipating map was created to represent Megan's anticipation activities within each lesson. These maps were based on

[7] A complete discussion of the distinction between active/purposeful and passive/incidental anticipating can be found in section 2.3.

the original anticipation framework presented in section 2.3, but only included the activities and SMRs that were anticipated for the specific lesson. The maps represent lessons and groups of lessons and allow for the viewing of Megan's practices across time. Figure 9 shows an example of such a map.

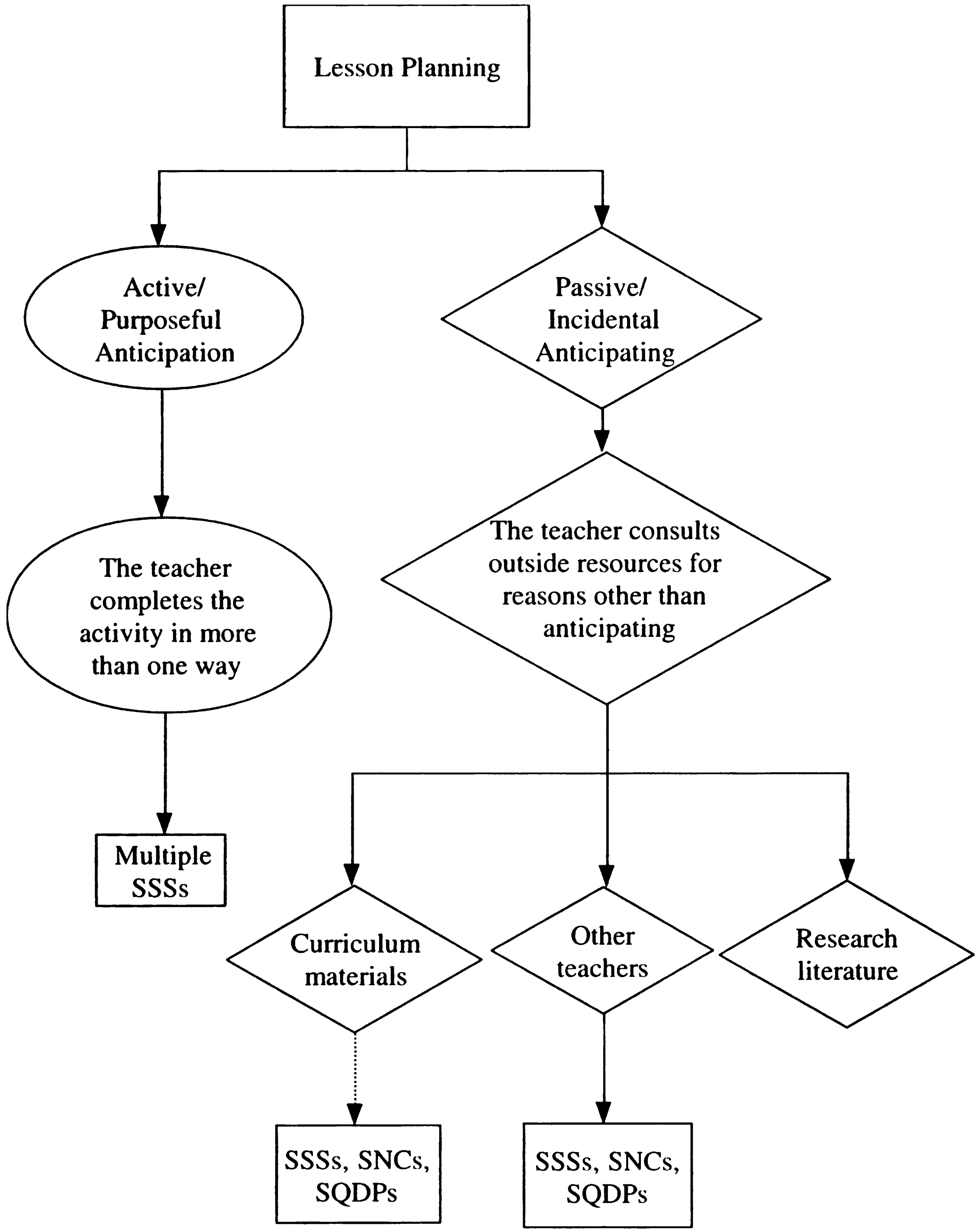

Figure 9. Example Anticipation Map

The active/purposeful side of Figure 9 represents that in this lesson the intern actively/purposefully chooses to anticipate multiple student solution strategies by

completing the task in more than one way. The passive/incidental side of Figure 9 represents that the intern used curriculum materials, such as the class textbook, in preparing the lesson, but that there is no evidence that doing so provided any information about SMRs, which is the reason for the dashed line, or that making use of the curriculum materials was done in order to anticipate SMRs. The passive/incidental side of the figure also shows that the intern consulted other teachers, again not in order to anticipate, but that in this case it led them to anticipate SMRs anyway, hence the solid line. Finally, the figure shows that the intern consulted research literature, perhaps to find an activity for the lesson, but that there is evidence that no anticipated SMRs came from this source.

Another data display that is used is a matrix in which the codes for each lesson were entered. An example of that matrix is represented by Table 2.

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Table 2. *Data Display for Anticipation Practices*

	Lessons
Active/Purposeful Anticipating The teacher consults outside resources in order to anticipate ▪ Curriculum materials ▪ Other teachers ▪ Research literature Completes activity in more than one way Takes position of students	
Passive/Incidental Anticipating The teacher consults outside resources for reasons other than anticipating ▪ Curriculum materials ▪ Other teachers ▪ Research literature Completes activity in only one way Takes position of students	
Outcomes of Anticipating SSS SNC SQDP	

Each cell contains counts of the number of codes and categories of each type appearing in each lesson. Although these counts were not statistically analyzed, they are included to provide the complete picture of the available data about the nature of Megan's anticipation of SMRs by showing the detail of her activities over the entire semester in one representation.

The anticipation maps and the matrix played an important role in describing the nature of anticipating. As Miles and Huberman (1994) point out "valid [qualitative] analysis requires, and is driven by, displays that are focused enough to permit a viewing of a full data set in the same location, and are arranged systematically to answer the resea

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research questions at hand" (pp. 91-92). The anticipation maps provide a visual snap shot of the anticipation practices at different points over the semester and the matrix allows for comparisons to be made across time.

A final data display consists of two mini-case studies within the larger case study that detail how various situations of anticipation play out in the intern's classroom. The first data analysis for this research question provided a picture of Megan's practices prior to teaching her lessons. The mini-cases take a slightly different look at the nature of anticipating by showing how the practice impacted Megan's teaching choices. These cases are based on the lesson plans, Pre-Lesson Interviews, and field notes from the class. Each mini-case details two distinct outcomes of anticipating SMRs.

3.4.1.3 Research Question 1 Conclusion Drawing

Conclusion drawing for the first research question came from analyzing the anticipation maps and the matrix for themes and changes in Megan's anticipation practices over the semester. This included an analysis of what was anticipated (solution strategies, naïve conceptions, or questions or difficult points) and the nature of what was anticipated (e.g. students may not remember procedures), as well as the resources that she used. Specifically, this included what type of anticipating occurred most over the semester and which resources she most often made use of and whether these resources helped her to anticipate SMRs. Additionally, the types of anticipating that rarely or never occurred were identified as well as which resources were not used.

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3.4.2 Analysis of Research Question 2: Factors of the Contexts

Research Question 2. What factors within the contexts of a teaching internship (a field experience and accompanying university course) promote or do not promote the practices of one preservice teacher anticipating students' mathematical responses during lesson planning?

The analysis of data to answer the second research question took place in two parts. The first part of the analysis produced a description of the various contexts in which the intern worked during the semester, which can be found in Chapter 4. The second part of the analysis resulted in an explanation of the influence of the contexts on the nature of the intern's anticipating, which is presented in section 5.2.

3.4.2.1 Describing the Contexts

This study involved a variety of people and settings. This section details the methods I used to describe each of these people and settings within the two contexts.

3.4.2.1.1 The University Context. The university context in this study was made up of the methods course, the methods course instructor, and the field instructor. Data used to describe the context came from transcripts of interviews with the methods instructor, the field instructor, field notes from observations of the methods course, transcripts of on-line chats from the methods course, and the collection of methods course assignments. Analytic summaries as described by Miles and Huberman (1994)were written for each methods course observation and the weekly on-line chats that identified the general themes of the interactions and how the practice of anticipation of SMRs was discussed or supported. The description of this context focuses on the general themes of th

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the course and the assignments, discussions, and models that related to the anticipation of SMRs.

3.4.2.1.2 The School Context. The school context in this study was made up of Logan High School, including the field placement classroom, and Megan's mentor teacher. Data used to describe this context came from the transcript of the interview with the mentor teacher, transcripts of formal conversations and notes on informal conversations between Megan and her mentor, and observations of the school context. The description of this context focuses on the generalities of working in the school along with the practices and norms that related to Megan's ability to anticipate SMRs.

3.4.2.2 Explaining the Factors of the Context That Promoted Anticipating

As with the analysis of the data for the first research question, Miles and Huberman's (1994) three activities for data analysis were used: (1) data reduction, (2) data display, and (3) conclusion drawing/verification. Data for this part of the analysis consisted of transcripts of interviews (Mentor Teacher Initial Interview, Field Instructor Initial Interview, Methods Instructor Initial Interview, Pre- and Post-Lesson Interviews, and In-Depth Lesson Interview 2), field notes from formal and informal conversations between Megan and her mentor teacher, the field notes from the methods course, transcripts of on-line chat room conversations, and written assignments from the methods course.

3.4.2.2.1 Research Question 2 Data Reduction. Within each of the data sources, including excerpts from conversations and interviews and assignments, influences on Megan's anticipation practices were coded using the zones described by Goos (2005a): the Zone of Proximal Development (ZPD), the Zone of Free Movement (ZFM), and the Zone of Promoted Action (ZPA). Goos (2005b) explains that the nature of the zones implies something unique which made coding less straightforward. "As the zones themselves are abstractions, this analytical process focused on the particular circumstances under which the zones were 'filled in' with specific people, actions, places, and meaning" (p. 45). Thus, it was often ideas represented by quotations, discussions, or assignments that were coded within these zones. In addition to being coded in the zones, the influences on Megan's practices of anticipating were further coded according to Engle and Conant's (2002) principles that foster productive disciplinary engagement[8]. In the ZFM this included influences that provided relevant resources and authority and in the ZPA this included influences that problematized mathematics and mathematics teaching and influences that held Megan accountable to the disciplinary norms of mathematics and mathematics teaching.

3.4.2.2.2 Research Question 2 Data Display. The data displays for the second research question includes several Venn Diagrams similar to those used by Goos (2005b) which represent the relationships between the zones (Figure 10).

[8] A full description of the zones can be found in section 2.1.

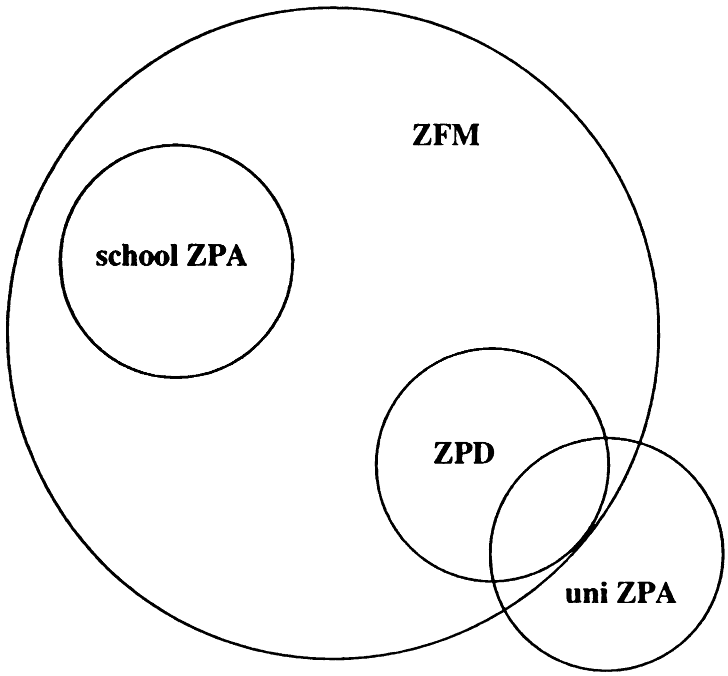

Figure 10. Goos' (2005b) Representation of ZFM, ZPD, and ZPA

Figure 10 represents how each zone was related for the novice teacher in Goos' study. Another data display is a matrix that displays the influences in the ZFM and ZPA and identifies each influence as either contributing to, or detracting from the practice of anticipating SMRs

3.4.2.2.3 Research Question 2 Conclusion Drawing. Finally, conclusions were drawn about the influences of the contexts on the nature of anticipating based on the description of the influences and the data displays. Specifically, which context included practices and supports that would promote an intern to anticipate SMRs and which did not.

3.5 Presentation of Findings

The current study aimed to describe the development of the practice of anticipating SMRs in a field experience using a situative perspective. The situative perspective as described by Greeno (1998) calls on researchers to begin by exploring the contexts and then narrowing the focus to investigate the influence of the context on the activities of individuals. Chapter 4 presents a description of the two contexts relevant to this study, the university and the school. This is followed by Chapter 5 which addresses the findings as they relate to the two research questions.

CHAPTER 4: THE CONTEXT

Because the theoretical frame that guided this study was a situative one, primary considerations include the settings and interactions that occurred during the field experience of the intern in question. Thus, before the case study findings of the intern teacher and her experiences are presented, I discuss two of the contexts in which she operated during the first semester of her internship, the university context and the school context. This is consistent with Greeno's (1998) chronology, "begin with the framework of interactional studies and work inward" (p. 6).

4.1 The University Context

The university context in which Megan operated during the first semester of her internship was comprised of three major facets. The first was the mathematics methods course and the instructor of that course. The second facet of the university context was the group of interns in this course, most of whom had been in classes together prior to this course and had formed a unique community of their own. The third and final facet of the university context was the university supervisor who was employed by the university but met with the interns in their field experience classrooms and supported them in their specific settings. The next sections describe each of the facets within the university context.

4.1.1 The University Methods Course

In many university teacher education programs all methods courses are completed before the final field experience. In this case, a sequence of methods courses were conducted before and during the internship year, providing the preservice teachers four semesters of secondary mathematics methods experiences, two during their senior year and two during their internship year. The methods course that took place during the internship year was taught by a university faculty member, Dr. Rundell. Dr. Rundell was the leader of the secondary mathematics team at the university and in that role he was responsible for the coordination of the curriculum for the mathematics methods courses and the field experiences. Dr. Rundell had taught the course once before and had also taught one semester of the senior year methods course at the university. He described his role in the course as, "supporting the interns in their first year of really engaging in teaching practice over the long term" [Methods Instructor Interview, October, 2008]. He saw this role as both encouraging the interns in terms of their long-term growth as well as addressing their immediate needs as they arose in the classroom settings.

Dr. Rundell designed five major assignments as part of the fall semester methods course which are summarized in Table 3.

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Table 3. *Summary of Methods Course Assignments*

Assignment	Description
Mathematics Teaching Philosophy	The first of three parts of creating a teaching philosophy. Parts two and three were completed during the spring semester. Interns described the beliefs and aims that undergirded their mathematics teaching practices.
Cool Stuff 1	The interns planned, using the lesson plan guide, and taught a lesson that both they and their students would find cool. For this lesson the interns were directed to find and modify if needed a task of high cognitive demand. (See Appendix J for full assignment description.)
Unit Plan	The interns created a plan for teaching a unit of content along with a concept map of the mathematical content in the unit and an assessment for the unit.
Cool Stuff 2	The interns planned, using the lesson plan guide, and taught a lesson that both they and their students would find cool. For this lesson the interns were directed to create a task of high cognitive demand and to make use of technology in their lesson.
Researchable Question 1	Groups of interns decided on a research question based on their internship classrooms, located and read research on student learning in that area, conducted a small research project, and presented their findings during a poster fair.

During the fall semester three intertwined foci of the methods course emerged. They were: (1) exploring proportional reasoning, (2) creating a collaborative teaching community, and (3) encouraging deliberate practices in planning, teaching, and reflecting on mathematics lessons. Each of these foci is further described in the following sections.

4.1.1.1 Exploring Proportional Reasoning in the University Methods Course

The first of the foci was the mathematical topic of proportional reasoning. As a part of this focus the interns worked together on mathematical tasks, read case stories of teaching and research literature in this content area, found instances of proportional reasoning in the textbooks they were using, and engaged in debates around important underlying questions of the mathematics such as "What is the difference between a fraction and a ratio?" These activities provided a venue in which the interns had the opportunity to both explore their own content knowledge and to discuss issues of teaching and learning.

Each time the interns worked on a mathematical task that provided the opportunity for multiple solutions they were asked in solve it in more than one way as is shown in Figure 11, a presentation slide from one of the classes.

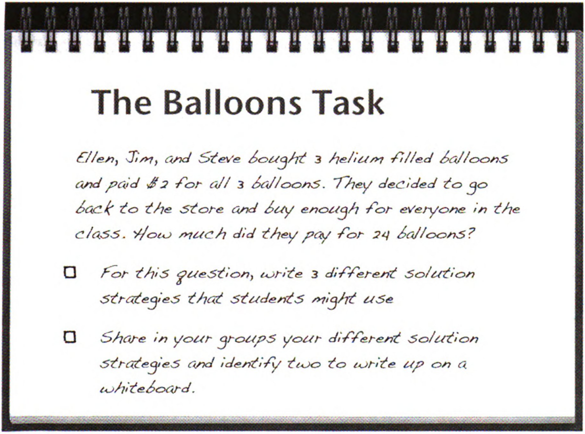

Figure 11. PowerPoint Slide of Directions for Solving the Balloons Task Asking for Multiple Solutions

During one of the problem solving activities, Dr. Rundell also encouraged the interns to consider incorrect ways to set up the problem and solve it. In addition to solving the proportional reasoning tasks in multiple ways, the interns also read case studies of teachers who used the tasks in their classroom or looked at multiple student solutions for the task. In all of these cases the task was solved in multiple ways, the interns' multiple methods were discussed, and multiple student solutions were discussed. While the focus of these activities was not solely on the possibility of multiple solutions, it was a recurring theme across the proportional reasoning activities. The next section describes the second of the focus of the methods course.

4.1.1.2 Creating a Collaborative Teaching Community in the University Methods Course

> The opportunity to share your thinking and have your ideas challenged by others is a critical part of developing as a teacher, and an experience that is often hard to come by in the normal course of the school day. This year, we will help you develop the *skills* for learning from your colleagues, and, perhaps more importantly, the *disposition* to do so, so that you can seek out or create these kinds of opportunities throughout your career. [Methods Course Syllabus]

The second focus of the methods course was on creating a collaborative community as described in the excerpt from the syllabus. The design of the methods course provided multiple opportunities for the interns to collaborate during and outside of class. During class the interns worked together to solve several mathematical tasks as described above. In addition to talking about mathematics, the interns discussed the teaching and learning of mathematics using case studies as well as case stories of their own teaching. In the case stories the interns shared their design and teaching of two

structured lessons referred to as Cool Stuff Lessons (see Hughes, Smith, Boston, & Hogel, 2008 for further discussion of case stories).

In addition to the discussions orchestrated during the methods course classes, there were three on-line opportunities for interns to collaborate, a weekly chat room, blog, and wiki. The weekly scheduled chat room, referred to as the fireside chat, took place every Wednesday night for two hours. Dr. Rundell was present at almost every chat and usually at least one or two course teaching assistants or field instructors were also present. This opportunity allowed the interns additional space and time to discuss their experiences outside of class. The blog was accessible by all of the interns as well as the secondary mathematics interns who had been part of the course in the previous year. Dr. Rundell described the purpose of the blog in the course syllabus in the following way:

> The blog is designed to accommodate narrative accounts of what's happening in our classes, so that we can all understand one another's classroom contexts. This fosters a sense of **a community of practice**, where we engage with one another around issues of teaching. [Methods Course Syllabus]

Current and previous interns had the ability to respond to each other's comments and concerns on the blog and some of the postings served as prompts for a weekly in class discussion in the methods course entitled *What's Happening in Math*. The blog allowed the interns to share their problems and ideas at any time and to receive responses from others when they had the opportunity to respond, unlike the chat which happened in real time.

Finally, the wiki was used as a place to share resources and collaborate on class assignments. While most of the resources, for example websites to find lesson plans and further information about ideas discussed in class, were posted by the instructors of the course, three interns chose to post their own lesson plans on the wiki to share with the other interns in the class. In addition to being a space for sharing resources, the wiki also contained pages for interns to collaborate on a group project and to give each other feedback on a lesson near the end of the semester. For the project the groups uploaded their plans for their Researchable Question 1 project as well as several pieces of research related to their area of interest. The interns also gave substantial feedback to two other interns on one of their lesson plans on one occasion in the wiki.

These settings often served as a place for the interns to share their "war stories" with each other and give and receive both support and advice. The interns' sharing was not limited to difficulties. In some cases they shared their perceived successes: "I started making my class student centered this week!" [Fireside Chat, September 17, 2008]. The topics were varied and often represented traditional teacher dilemmas around assessment, classroom management, working with other teachers (most often the mentor teacher), motivating and engaging students, and communicating with parents.

In addition to the sharing of stories, certain aspects of professional collaboration were modeled for the interns by the instructors in the various settings. This mainly happened through the sharing of resources and group problem solving. A list of resources for finding tasks, titled *A Treasure Trove for Tasks*, was placed on the wiki. In addition, there were several instances during chats when Dr. Rundell emailed a task or other resource to an intern in need of help.

The types of problem solving that were modeled were based on the immediate concerns that the interns brought with them to class or one of the other setting. In one example from a Fireside Chat an intern, Jane, expressed her frustration about her students understanding of multiplication. Two field instructors, Alex and Emily, helped her clarify her problem and then offered some suggestions[9]. Megan also added what she had heard about the subject area to the conversation. The following is from the chat log of this conversation.

Jane:	It is troubling for me, to think that my students don't know or understand multiplication.... I feel they should know this by now. Why haven't earlier teachers corrected this?...
Alex:	"Don't know" is a bit broad of a statement. Can you clarify what you mean?
Megan:	I have heard from various teachers that they have tried to get students in high school to learn their multiplication tables and they have had difficulty with it. This is interesting to me
Jane:	for instance... if I asked them what [three times five] was, it takes them a minute... most look up at the stupid multiplication posters that are posted...
Emily:	What do you think about the fact that the multiplication posters are posted? Would you post them in your room?
Jane:	heck no... they post them because students need them to do the math they are learning today
Emily:	What do the students do if it's not on the poster? like [74 times four]
Jane:	they would want to use a calculator
Emily:	What do you do then?
Jane:	it's all about getting the "answer" the quickest way. I say no way jose! and make them do it longhand...
Emily:	So they know how to do it longhand?
Jane:	yup
Emily:	Do you ever have opportunities to think aloud (model) other strategies than the algorithm?

9 Names used for interns, instructors, mentor teacher, and school are pseudonyms throughout.

Jane: They understand the algorithm for doing it. For instance 74+74+74+74?. I am trying to think another way for them to do it, because I don't know these other ways.

Alex: 70*4+4*4...(Distributive property)

Emily: 74*2 then *2 again

Jane: I gotcha... no... we never do this in these ways. They just learned the distributive property in the beginning of the year and they really didn't get that either.

Emily: This might be a good exercise to help show the students the other ways that they might breakdown the problem to make sense of it and make it more reasonable to solve. You could even include one (periodically) during your warm-up activities.

Jane: okay

Emily: As a way of fitting into your existing routine.
[Fireside Chat, October 29, 2008]

In this interaction the field instructors challenged Jane to think more deeply about her students' understanding of multiplication and offered her some ideas to try.

In addition to being modeled by the instructors of the methods course, both of the practices of sharing resources and problem solving were also evident in the practices of the interns which will be discussed in a later section. The next section describes how the Plan, Teach, Reflect cycle, which was originally introduced in the senior year methods course, was carried through into the intern year methods course.

4.1.1.3 Encouraging Deliberate Practices in Planning, Teaching, and Reflecting on Mathematics Lessons in the University Methods Course

The final focus of the methods course was on participating in deliberate teaching practices in order to improve student learning of mathematics. The routines that were expected of the interns in this area were modeled by the instructors and discussed in the class. These routines were based on two frames that were familiar to the interns from their work in the senior year methods course. The first was the five practices model presented by Stein, Engle, Smith, and Hughes (2008) and the second was a lesson planning model based on a cycle of planning, teaching, and reflecting. Dr. Rundell describes the incorporation of these two models in the class structure in the following way:

> Really everything that we do in class is about these two frames, and the five practices is one of them that kind of fits at the lesson level, and a lot of what we do relates to that. And then the planning, teaching, and reflecting cycle is another one that comes up often and is kind of the larger level up. But those are the reoccurring structures in the class, both in terms of how we are asking them to think about lessons and units and investigating their own teaching and thinking about their own identity as a learner. [Methods Instructor Interview, October, 2008]

The Plan, Teach, Reflect cycle was carried out in both the Cool Stuff 1 and Cool Stuff 2 lessons. The interns were required to use a particular lesson plan format (see Appendix B) for the plan phase of the cycle and for Cool Stuff 1 they shared their ideas with other interns in class before teaching in order to elicit additional support during the planning process. In designing a lesson for the Cool Stuff 2 assignment, the interns posted their lesson plans on the wiki and received feedback from their peers and an instructor. After teaching each of these lessons the interns reflected individually on what occurred during the class and on their own teaching. In addition to individual reflection, after teaching Cool Stuff 2 the interns spent time in class debriefing with other interns in small groups about what happened. For both Cool Stuff 1 and Cool Stuff 2 the interns were expected to make use of educational research literature to analyze their students understanding using evidence they collected during class.

The other frame that focused the interns on deliberate practices of teaching was the five practices model. The interns were familiar with the five practices model from their work in the senior year methods course and Dr. Rundell expected them to build on these practices. Dr. Rundell assigned the article by Stein, Engle, Smith, and Hughes (2008) for reading to remind interns of the five practices and then focused part of his feedback to their Cool Stuff lesson plans on whether they had addressed the practices. As the first of these practices that lays the foundation for all the others, anticipating students' mathematical responses (SMRs) was a practice that received special emphasis. Dr. Rundell stated specifically that he looked for evidence of anticipating SMRs, in particular,

> I talked about both considering misconceptions and accurate conceptions, is a way to think about it. Productive ways of student thinking that may come up...if it's a task that has multiple solution paths I look for [whether they have] thought about three or four or five really good solution paths. If it's a mathematical idea that I know from research or from experience that has a lot of student misconceptions I look for did the task really invite particular student misconceptions. [Methods Instructor Interview, October, 2008]

In addition to early feedback aimed at helping the interns think about anticipating SMRs, Dr. Rundell also emphasized the importance of the practice in the evaluation rubric for the Cool Stuff lessons (see Appendix J). Five elements are evaluated in the planning portion of the rubric: (1) the statement of the mathematical goal, (2) building on prior knowledge, (3) inclusion of materials and launch, (4) task selection and setup, and (5) anticipated student questions/thinking. The statement of the mathematical goal was worth one of the potential ten planning points. Building on prior knowledge, inclusion of materials and launch, and task selection and setup were each worth two of the potential ten points. The last category in the planning portion of the rubric, anticipated student questions/thinking, was worth three of the potential ten points. The relative number of points awarded for anticipating SMRs indicated its importance as a lesson planning practice in the course.

The focus on deliberate practices was evident throughout the course and was emphasized in all phases of the Plan, Teach, and Reflect cycle. These deliberate practices were further spelled out in the five practices model that the interns were expected to make use of in their lesson planning. Within the cultivating of these deliberate practices in the methods course, the practice of anticipating SMRs was given special focus as the foundation of the other practices. In addition, the creation of the collaborative community and the focus on mathematics throughout provided many opportunities for the interns to share and discuss mathematical ideas that would benefit them in anticipating SMRs in the future. The next section describes the intern group and how they participated in their collaborative community.

4.1.2 The Interns

The interns in the methods course created a unique community of preservice teachers. Fifteen of the 17 interns in the class were part of a class that completed the senior level methods course sequence the previous year. The two other interns had completed the sequence one year earlier. Although these two interns were not part of the original group, their substantial participation in class and the online chats and blogs could be interpreted as evidence of their comfort with the larger group of interns.

The group of interns participated in the practices of a collaborative community modeled by their instructors, including the practices of problem solving and resource sharing. In one Fireside chat an intern, Danielle, expressed the need for a math game and another intern, Brian, responds with an idea.

Brian: I like the factor game

Danielle: what's that? (and that's perfect, cause we just did our section on factoring last week)

Brian: http://illuminations.nctm.org/activitydetail.aspx?ID=12. There is a link to the factor game, its pretty fun.

Danielle: awesome [Fireside Chat, October 29, 2008]

In another interaction in a Fireside chat Danielle was having problems motivating students. Another intern, Todd, tried to help her think about her situation.

Danielle: I think they're lazy...that's the biggest problem...I could give them another 5 days, and I don't know how much of a difference it would make. There are students that put in the effort, come in for help, participate and ask questions in class...the rest of them...not so much.

Todd: That's an interesting assumption you have there What makes you think they are lazy instead of just say...frustrated and shy?

Danielle: I think it's a vicious cycle....the more I try to "help" them....by giving them this practice quiz, or spelling out things in the lesson, the less work they wanna do... they're definitely not shy... frustrated maybe... but they don't like to put in the effort....when we go over homework, we go through every answer...

Todd: They may not be shy about talking in class, they could be shy about asking for individual help.

Danielle: some students, if they get one question wrong, they want me to go over it...but they'll make a little mistake like adding 1+ -2 = 1, and they don't even try to see what they did wrong first, they just want me to do it for them...I don't know...I'm not used to students who don't have at least some self motivation it's very different from my high school growing up

Todd: So, didn't get right answer means "out of my hands, help me teacher?"

Danielle: yeah, that's probably a good way of putting it [Fireside Chat, November 19, 2008]

Their conversation continued and Todd asked if it was possible that the students at Danielle's school are motivated but they have not had the same experiences learning to "play school" that many of the interns had. In this interaction Todd challenged Danielle to reconsider the way she was thinking about the problem with her students.

The interns also often engaged in discussion about the mathematics and student learning in their classrooms, both when prompted to do so and without being prompted. One example of two interns discussing student learning on their own occurred early in the semester. The two interns were writing a mathematical solution to a problem on a white board near the back of the classroom. As the other interns finished writing their solutions on other boards around the room the two interns began to talk about what they were teaching in their classes. Both were teaching students to use rulers in their field placement classrooms. One of the interns shared with the other a specific difficulty he noticed that his students had when trying to learn to use a ruler.

Overall, the interns were quite cohesive as a group and though their interactions with each other demonstrated facets of a teaching community of practice. The next section describes the university field instructor who worked with Megan during the semester.

4.1.3 The University Field Instructor

A total of six field instructors worked with the group of secondary mathematics interns. Megan's field instructor, Emily, attended each meeting of the methods course and was present in all of the fireside chats. Although this was Emily's first year serving as a university field instructor, she had previously taught several years of high school mathematics and thus brought a wealth of experience to the position. The teacher education program handbook describes the role of the field instructor in the following way:

> Make at least five scheduled observation visits each semester and hold five conferences with the Intern and Mentor Teacher during the year. They supply program information, offer an additional perspective on classroom events, and support interns in meeting the program standards. [Program Handbook, p. 5]

Emily voiced her own perception of her role as a field instructor:

> I think it's my responsibility to facilitate communication between the cooperating teacher and the university and also to provide support to the intern with respect to how they're designing lesson, how they're implementing lessons, and give them constructive feedback on those things. [Field Instructor Interview, September, 2008]

The majority of the conversations between Emily and Megan around Megan's teaching took place at the field placement school. When Emily traveled to Megan's field placement she always observed her teach a class, usually the Focus Class. After observing Megan teach, Emily and Megan would debrief about the class and talk more generally about Megan's experiences. Emily would ask Megan how she felt the class in particular went and how things were going more generally. She would also question Megan about the class activities that were part of the mentor teacher's regular schedule that she had adopted and other choices she made on her own. These debriefs served as an opportunity for Megan to ask Emily questions about what she was doing and to ask for advice about how to do things differently. For example, Megan was asked by her mentor teacher and the school principal to tutor a student during seventh hour who had been absent for several days in order to catch her up. Megan was concerned that the student was missing the new content in the class and Emily was concerned that Megan was missing an opportunity to watch her mentor teacher teach. The debrief conversations offered Megan an opportunity to discuss these types of problems and brainstorm solutions with an experienced teacher. Many of the conversations between Megan and Emily resulted in Megan voicing her desire to teach in what she termed a "more student-centered way."

In addition to discussing Emily's observation during these meetings Emily also commented on Megan's lesson plans that were collected and organized in her Focus Binder. Emily noted that in her first meeting with Megan she made a suggestion to her about her lesson plans.

> I gave her feedback about she needs to write down some more questions and stuff to help prove to me that she's thinking through her lessons. [S]he's doing all of the math that... the kids are doing, ahead of time... she's solving them all out so [I suggested that she] spend half the page doing the math and then the other half of the page writing down things that you think are going to be problematic or questions that you are going to ask to push student thinking. [Field Instructor Interview, September, 2008]

Emily had as a goal for all of the interns that she served as a field instructor for that they would eventually be able "to predict the questions that the students are going to ask and the misunderstandings that they are going to have" [Field Instructor Interview, September, 2008]. Emily's interactions with Megan mirrored those that took place in the methods course. She attempted to engage Megan in problem solving conversations similar to those that took place in class and in the chats. In addition to this she served as an additional support resource by pointing out areas for improvement for Megan, including anticipating SMRs more often in her lesson planning. The next sections shift in focus from the university to the school context and describe the settings and interactions that Megan participated in while at Logan High School.

4.2 The School Context

The school context in which Megan operated during the first semester of her internship was also comprised of three major facets. The first was the school itself, Logan High School. The second facet of the school context was the mentor teacher with whom Megan worked during her internship year and whose classes she taught. The third and final facet of the school context was the Focus Class that Megan taught throughout the year. The next sections describe each of these contexts.

4.2.1 Logan High School

Logan High School was housed in a large new school building with students in grades nine through twelve in attendance. It was located in a small rural village in the Midwest and is the only high school in the district. The hallways were clean and colorfully decorated with student work from different classes. The staff and faculty of the school were friendly and always willing to help a visitor find where they needed to be. The mentor teacher described the other teachers in the building as proactive, positive, and not afraid to incorporate new things into their classrooms. Students often arrived at school early and sat in the open cafeteria and talked with each other before the school day began. Megan's mentor teacher, Mrs. Starns, explained one positive outcome of the new building:

> It has everything you could possibly want and it's a beautiful layout. I think it lends itself for kids to really like to be here because it's clean and fresh and that

> kind of thing. We have a beautiful gym, we have a walking track and that's a nice feature. And then we have the various groups, like cheerleading has a room and wrestling has a room and there's a weight room. So it really does for those parties or distinct groups, they do have their place. So I think people feel they have a place in the building. [Mentor Teacher Interview, October, 2008]

The school's principal was young and welcomed the idea of research taking place in his school.

The students in the high school were also very friendly. In their ethnicity, more than 94% of the students at Logan High School were Caucasian and according to the mentor teacher they came from economically diverse backgrounds. Approximately twelve percent of the students received free or reduced lunch. A relatively large group of the students lived in different parts of the country during the year depending on where their parents were needed for farm work. These "migrant students" only attended Logan High School during the first quarter or semester and then they moved to another location. Other groups of students live on local farms, ranging from very small to very large and prosperous, and another group of students live in the town.

The students in the school displayed their school spirit by wearing school tee-shirts and sweatshirts and creating large banners to display in public places. During the semester of data collection the football team was having a winning season and the students in the school were visibly excited at the prospect of the team making it to tournament games. Megan and Mrs. Starns both attended many of the football games and they often joined with the students in talking about the exciting things that happened at the games on Monday morning.

The math department staff at Logan High School was made up of three teachers. These teachers met once a month through a professional development program sponsored by a local collaborative of school districts. Mrs. Starns noted that if it were not for these monthly meetings, the three math teachers in the department would not have the opportunity to interact. She also described their teaching philosophies as being very different, ranging from very straight forward teaching to trying new activities all of the time. Megan's perception of the mathematics department was somewhat different, as she described it to her peers in the methods class, the "math department is very lecture-based" [University Methods Course, September 26, 2008].

4.2.2 The Mentor Teacher

Megan's mentor teacher, Mrs. Starns, had been teaching at Logan High School for over 15 years. Prior to the beginning of her teaching career she received her undergraduate degree in mathematics with a minor in physical science from the same university Megan attended. Several years ago she completed a masters degree in general science with an emphasis in physics and astronomy from another local university. During the semester of data collection she was working on a masters degree in educational administration from a third local university. Working with Megan was her first time serving as a mentor teacher.

Mrs. Starns appeared to have a warm relationship with most of the students. Former students stopped by her classroom to talk with her about the events in their lives. Occasionally at lunch time several students would come to her classroom to sit with her and eat lunch. Mrs. Starns seemed to be familiar with many of the students in the school and their families.

Mrs. Starns' taught three periods of Algebra 2, one period of Math Analysis (a class which is comparable to Pre-Calculus), one period of Calculus, and one period of Physics. Her teaching in the mathematics classes appeared to be based mostly on lecture while her teaching in the physics class appeared to branch out more, making use of different technology and other physical examples such as bow and arrows and trebuchets that students brought in for one of the Physics units. This difference in teaching style might have been due to her own conception of mathematics which she described to Megan as "the most boring subject" [Informal Conversation, Lesson 1.4 Observation].

Mrs. Starns created and followed a weekly schedule in all of her classes. The schedule that she used in Algebra 2 and was posted on her school website was:

Monday: Bellwork, Worksheet, Textbook Homework

Tuesday: Worksheet Due, Vocabulary Quiz, Textbook Homework

Wednesday: Bellwork, Quiz, Class Game

Thursday: Bellwork, Textbook Homework

Friday: Bellwork, Game of Life Mobile, Notebook Check, Every three weeks there is a test on this day.

Megan and Mrs. Starns had limited time before and after school to work together to plan lessons. Thus, most of their common planning time took place during fifth hour which is Mrs. Starns scheduled planning time. The planning conversations between Mrs. Starns and Megan tended to focus more on what was going to be taught or happen (i.e. "we will do section 3.2 on Thursday" or "I am going to use this activity") as opposed to how it would be taught or how students might respond. On occasion Mrs. Starns shared some general observations from her experience with Megan about the content in the Focus Class. For example, she shared with Megan that the chapter on quadratics was traditionally "so confusing for kids" [Methods Course Observation, December 5, 2008]. The opportunity for Mrs. Starns to provide feedback on Megan's teaching was also limited to a degree. Mrs. Starns participated in several professional development programs that occasionally kept her away from the school. In addition, she often worked with struggling students in another room while Megan was teaching.

Mrs. Starns was very clear about her expectations for Megan's development during the beginning of the field experience.

> I really want her to focus [during] the first marking period on instruction, [such as] getting herself to speak well, to speak clear, to get directions out. I think that's really important. The little stuff, the nitpicky stuff, it's important but you have to do it in layers. So I think the very first layer that she has to get accustomed to is gaining [students'] attention and being confident in the activities that we are doing and the material that she is teaching. It's an overall respect that you have to gain from the kids and [you need to] be able to project yourself as a strong person and a strong woman. And that's my push for her this marking period. And [also] to be more clear and concise and less 'uhhhh,' and that kind of thing. [Mentor Teacher Interview, October, 2008]

She also stated that as the year went on she thought Megan would need to spend less and less time on her lesson planning as she learned how to present material.

Mrs. Starns was very vocal with Megan about how she felt about the expectations of the field instructor, and by extension the university. She was concerned that the university field instructor may not have had adequate experience to advise Megan because she had not taught as long as Mrs. Starns thought necessary. One day after they had discussed some of the field instructor's ideas for improvement Mrs. Starns told Megan "don't let her bother you too much" [Informal Conversation, Lesson 1.3 Observation]. In addition to stating her concerns about the university ideas to Megan, Mrs. Starns also chose to conduct Megan's field experience in slightly different ways than the university prescribed. For example, Megan began teaching her focus class in the

third week of school instead of the first. In another instance, Mrs. Starns had Megan grade the papers for all of the Algebra 2 classes and part of the Math Analysis course so that she could get used to the grading load early in the school year instead of only being responsible for her single Focus Class. Mrs. Starns comments and actions gave the impression that she had different priorities for Megan's development than those voiced by Emily and Dr. Rundell. The next section describes the class that Mrs. Starns and Megan chose to be Megan's Focus Class during her internship.

4.2.3 The Focus Class

Megan's Focus Class was an Algebra 2 class made up of twenty-three students, eleven males and twelve females. Four of the students in the class received separate accommodations and were either not physically present in class or were working on their own material. Two of the students were "migrant students" and usually spend the entire class period with a special "migrant teacher." The other two students also attended the local career center and were usually pulled out by the mentor teacher and worked with individually during the class. The students sat at desks that were arranged in pairs and faced an overhead projector. The class also had an LCD projector mounted to the ceiling which was mostly used to display the bell work from a Word document at the beginning of each class. Along one side of the classroom was a bank of cabinets. One of the doors was labeled "Physics CBRs." This technology was used in Mrs. Starns's physics class prior to one observation, but never in the mathematics classes. The main technology used in the class was the TI-84 calculator that was used individually by the students and at the overhead projector as a presentation tool. The walls were decorated with bright posters and there were student created mobiles hanging from the ceilings that students took down and used when playing the Game of Life, a simulation game in which students kept a checkbook and make deposits and withdrawals each Friday based on the number they rolled on a dice.

The Focus Class uses the McDougall Littell Algebra 2 textbook (2004). During the first semester the Algebra 2 course focused on the following chapters from the textbook:

Chapter 2. Linear Equations and Functions

Chapter 3. Systems of Linear Equations and Inequalities

Chapter 4. Matrices and Determinants

Chapter 5. Quadratic Functions

Chapter 7. Powers, Roots, and Radicals

Chapter 8. Exponential and Logarithmic Functions

Following Mrs. Starns's schedule, each chapter was taught and tested in a three week period.

The students in the Focus Class mostly were cooperative with Megan, although on occasion they would conduct short side conversations that hardly ever reach the point of disrupting the class. Often before class began the students would ask Megan questions about their homework or engage her in conversations about the school football game or other out of school activities. When Megan moved outside Mrs. Starns's normal schedule and structure and asked the students to participate in activities instead of take notes, the students appeared to do so willingly. For example, Megan asked students to participate in a skit to introduce her Cool Stuff 1 lesson. She had no problem finding students to volunteer or in keeping the other students engaged during the activity.

4.3 Summarizing the Contexts

The university and school contexts in which Megan participated offered her a variety of perspectives and opportunities. The university supported her by providing a collaborative community and experiences that challenged her to think deeply about her practices. The school supported her by providing a pleasant setting for her to work with cooperative students and a practicing teacher to give "on the ground" advice. Despite both contexts providing important opportunities for Megan to learn about teaching mathematics, they presented significantly different perspectives in several areas. The university context modeled a sharing and problem solving community of teachers. The school context did not model this type of community, either in the math department or in the interaction between Megan and her mentor teacher. The other important difference in the two contexts was their focus on a different set of skills for Megan to develop. The university context supported the development of deliberate and thoughtful practices of teaching that revolve around mathematics. The school context supported the development of Megan's general presentation skills and "getting her up to speed" with the daily responsibilities of a teacher.

CHAPTER 5. FINDINGS

The findings of the study are organized into two sections that correspond to the research questions.

1. What is the nature of a preservice teacher's practice of anticipating students' mathematical responses during lesson planning over the first semester of her field experience?

2. What factors within the contexts of a teaching internship (a field experience and accompanying university course) promote or do not promote the practices of one preservice teacher anticipating students' mathematical responses during lesson planning?

The first section describes Megan's anticipating practices and presents two mini-cases that illustrate the impact of Megan's anticipated students' mathematical responses (SMRs) during the lesson enactment. The second section focuses on the interaction between Megan's practices of anticipating SMRs and the contexts in which she was working. This section is organized by each of the zones outlined by Goos' (2005a) framework: the Zone of Proximal Development, the Zone of Free Movement, and the Zone of Promoted Action[10].

5.1 The Nature of Anticipating

Research Question 1. What is the nature of a preservice teacher's practice of anticipating students' mathematical responses during lesson planning over the first semester of her field experience?

The following sections present snapshots of Megan's practices of anticipating SMRs during lesson planning at several points over the first semester of her internship experience. The primary focus of this section is on the anticipation practices that occurred

[10] Chapter 2 provides a summery of Goos' (2005) framework with a description of each of the zones.

prior to the teaching of each lesson along with the content of what was anticipated. A secondary focus of this section is a set of two mini-cases that illustrate the outcomes of Megan's anticipation of SMRs in her enacted lessons. The mini-cases move beyond the description of what Megan anticipated and the resources she made use of, into how she enacted the two lessons to account for what she anticipated. The first seven sections that describe Megan's anticipation practices are presented chronologically.

5.1.1 In-Depth Interview 1

The first in-depth interview took place in late September during Megan's second full week of teaching. During this interview Megan responded to questions about her answers to questions on the Lesson Planning Survey (LPS) as well as about a lesson she brought to the interview that she planned to teach the next day. Megan's responses during this interview indicated that for this lesson plan she anticipated students' mathematical responses (SMRs) both actively/purposefully and passively/incidentally[11]. The lesson she described focused on graphing and solving systems of linear inequalities and Megan explained that it would be presented to students via lecture and that they would be responsible for taking notes. Figure 5.1 represents Megan's anticipation of SMRs for this lesson with callouts that display Megan's own words. Also included in Figure 12, in the upper right hand corner, is the entire anticipation framework with Megan's actions for this lesson in grey, and the actions she did not take in white.

[11] Refer to section 2.3 for a description of the framework used to classify Megan's anticipation practices.

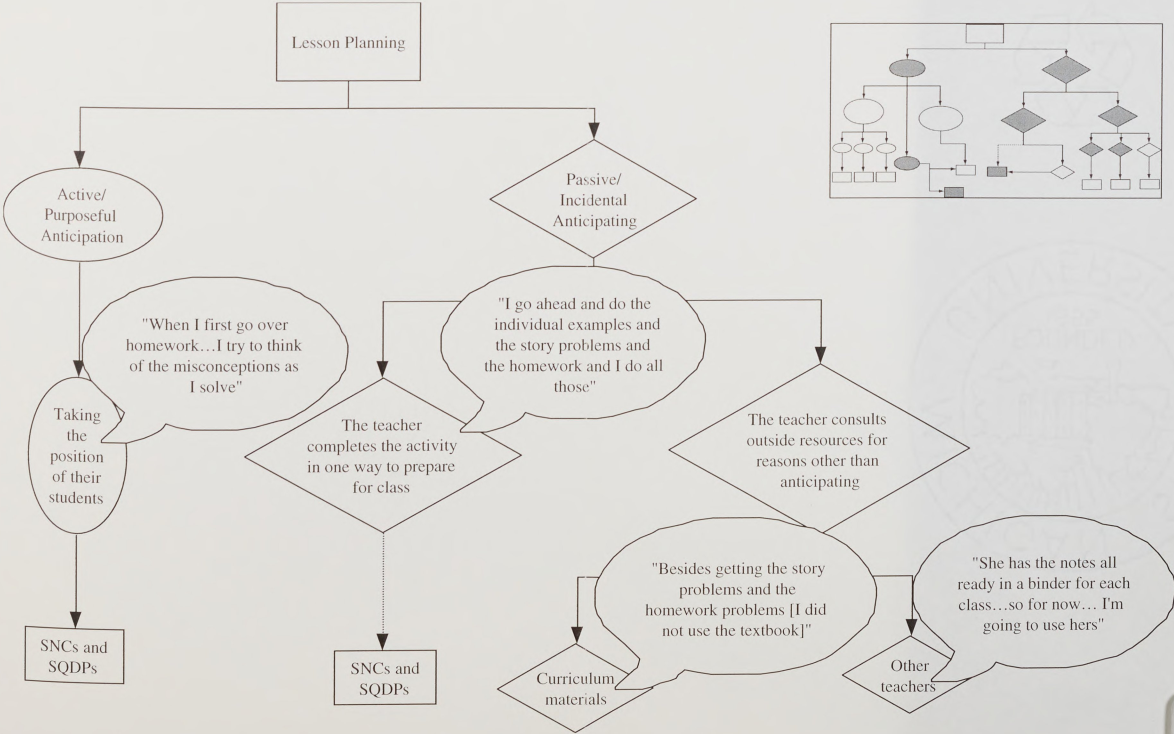

Figure 12. Anticipation Map for Lesson Discussed During In-Depth Interview 1

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The left side of Figure 12 represents Megan participating in active/purposeful anticipation and that those activities lead to possible SMRs. Evidence for this finding is based on Megan's responses to why she included certain SMRs in her lesson plan. "Because you want to [think about] misconceptions, that's just a given, you want to find out how to answer [the students] questions. When I first go over homework...I try to think of the misconceptions as I solve" [In-Depth Interview 1, September, 2008].

The right side of Figure 12 represents Megan's passive/incidental activities in anticipating SMRs for this lesson. As the figure shows, she indicated that she completed the task herself, consulted the class textbook (*curriculum materials*), and used Mrs. Starns' notes (*other teachers*) when planning this lesson. The dashed line from *The teacher completes the activity in one way to prepare for class* indicates that this activity potentially led to Megan's anticipation of SMRs, but there was no direct evidence that it did. The next paragraph describes the student questions and difficult points (SQDPs) Megan anticipated the students would have. While she linked one of the two student questions or difficult points (SQDPs) specifically with trying to think of misconceptions, she did not link the other with any specific reason or resource for anticipating. There is no line connecting *curriculum materials* or *other teachers* to anticipated SMRs because Megan's own words revealed that she did not use these resources in this way. Megan indicated that in planning this lesson she only used the classroom text to "[get] the story problems and homework problems" [In-Depth Interview 1, September, 2008]. The use of Mrs. Starns' class notes from previous years was included in using other teachers as resources since Megan chose some of the examples in her own lesson plan from those notes.

Megan identified two SQDPs during the interview. The first related to solving inequalities, "I think they might have problems with flipping the sign, like when they divide by a negative" [In-Depth Interview 1, September, 2008]. Though this particular SQDP represented content that was integral to what Megan was teaching in the lesson, it was also content that the students likely learned in Algebra I. Megan indicated that the mathematics that came before this lesson focused on systems of linear equations, thus the students had likely not reviewed anything about linear inequalities in class. This SQDP did not represent the new content that students would be learning in the lesson, namely the graphing and solving of systems of inequalities. Thus, in this case anticipating was focused on whether the students would remember previously learned procedures in order to be able to make use of them in the current lesson.

The second SQPD that Megan anticipated related to "knowing how to shade things, like when it's greater than you go above it and if it's less than you do it below" [In-Depth Interview 1, September, 2008]. Since Megan indicated that the students had never before worked with an inequality in two dimensions, this SQDP represented Megan anticipating SMRs based on the current content of the lesson, but like the first SQDP focused on a procedure. The next section described Megan's practices of anticipating SMRs during the first set of classroom observations and interviews.

5.1.2 Observation 1

The first set of lesson observations and interviews took place over a one-week period in late September and early October, during the fifth week of the school year. This was Megan's third full week of teaching the Focus Class. During this week, Megan

followed Mrs. Starns' weekly schedule and two sections of the class curriculum were taught from the textbook as was the norm in the class. Table 4 shows the activities of the week.

Table 4. *Schedule of Class Activities during Observation 1*

	Lesson Number and Class Activities
Monday	Lesson 1.1 (Linear Programming) Lecture and note taking
Tuesday	Lesson 1.2 Review of previous night's homework
Wednesday	Lesson 1.3 Quiz Class game
Thursday	Lesson 1.4 (Graphing Linear Equations in Three Variables) Lecture and note taking
Friday	Lesson 1.5 Game of Life Notebook check Introduction to Election Project

Only Lesson 1.1 and 1.4 were analyzed for the nature of anticipating because the other classes did not engage students in new mathematics. In preparation for these two lessons Megan participated in only passive/incidental anticipation, anticipating SMRs related to past and current content, and making use of resources available at the school.

Lesson 1.1 was taught on Monday and focused on linear programming and Lesson 1.4 was taught on Thursday and focused on plotting single points in three dimensions and then graphing equations in three variables. Both lessons were taught via presentation of examples while the students took notes. Figure 13 displays the anticipation map for these two lessons.

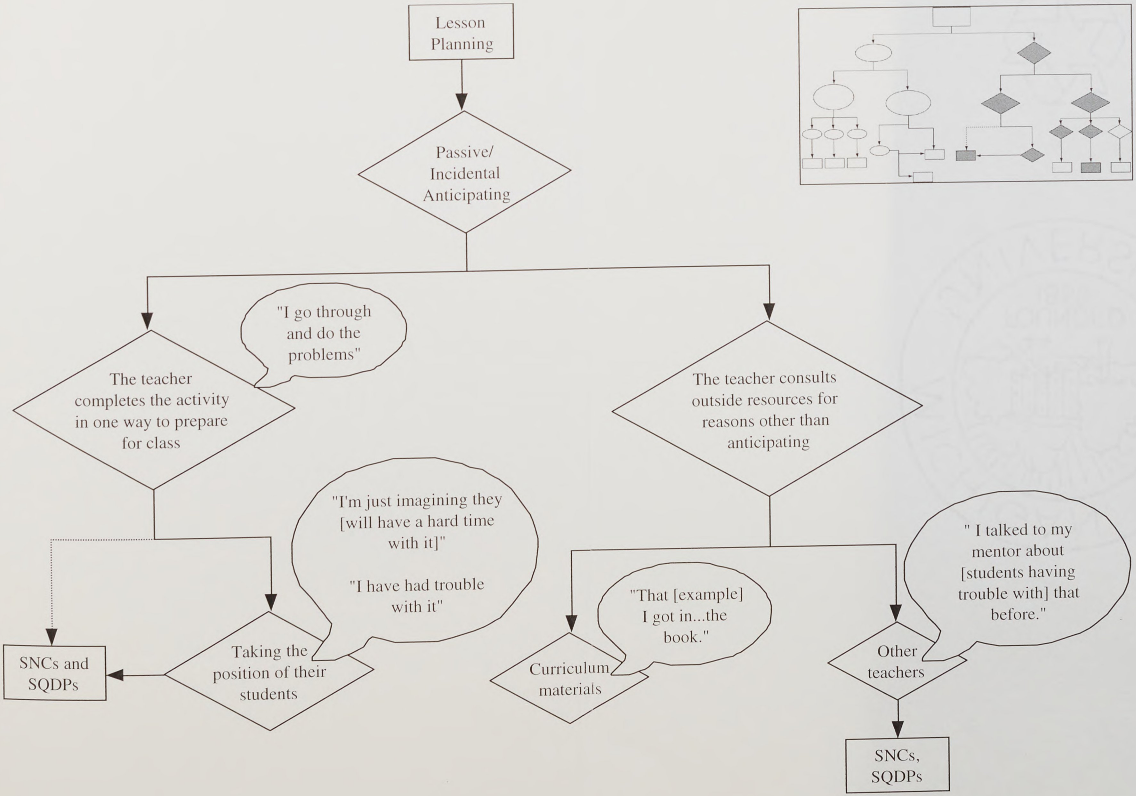

Figure 13. Anticipation Map for Lessons 1.1 and 1.4

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Figure 13 displays all of Megan's anticipation activities for Lesson 1.1 and Lesson 1.4. The small representation of the entire anticipation frame in the upper right hand corner of the figure shows that all of Megan's anticipation activities took place on the right, or passive/incidental, side of the framework. Prior to teaching Lesson 1.1 Megan solved all of the problems to be completed in front of the class, discussed the lesson with her mentor teacher, and used Mrs. Starns' notes from previous years to find examples. From speaking with her mentor teacher and "just imagining" Megan anticipated a potential SQDP, namely that students would have trouble knowing when to use a dashed or solid line when graphing inequalities. Megan's imagining is represented in Figure 13 as *Taking the position of their students* because she indicated that she had not yet had a chance to see the students work in this area and so had no prior knowledge, she just imagined they struggled with it in the homework. She also anticipated that students might struggle to visualize the constraints when graphing equations and knowing which side to shade when graphing an inequality. As with the lesson discussed in In-Depth Interview 1, the struggles that Megan anticipated for this lesson included recalling past mathematical content that the students should have previously learned.

In preparation for teaching Lesson 1.4 Megan completed all of the examples that she would present and students would copy during her lecture, talked with her mentor teacher about teaching the concepts, looked in the textbook for problems to use, and reflected on her own learning of the concepts. Her anticipating for this lesson again focused on SQDPs but also included a possible student naïve conception (SNC). The SNC that Megan anticipated dealt with students understanding of what constituted a solution in three dimensions. "Because they're used to graphing lines…and now they

have to realize that the solution is a plane and not a line and that it equals everything in the plane. And I don't know, sometimes they're like 'oh its just the points' or 'oh its just the lines with the points' but it's everything" [Lesson 1.4 Pre-Interview, October, 2008]. In addition to anticipating this possible SNC Megan anticipated that the students would struggle with the addition of the z-axis to the coordinate plane; "the kids have trouble visually seeing [three dimensions]" and she noted that she knew this because when she reflected on her own learning she recall that "I have had trouble with it" [Lesson 1.4 Pre-Interview, October, 2008]. She also anticipated that the students would struggle to see z as a function of both the variables x and y. As with the previous lesson, Megan's anticipation focused both how students would respond to the new content being taught that day and whether they would remember the procedures of past content. The next section describes Megan's anticipation of SMRs during the planning for her first university lesson assignment.

5.1.3 Cool Stuff 1

The first Cool Stuff lesson took place one week after the first week of observations. In preparing for this lesson Megan participated in both active/purposeful and passive/incidental anticipating. Instead of teaching new content, Megan used the Cool Stuff 1 assignment to create a review activity for an upcoming test. The SMRs that she anticipated for the lesson reflected this in that some of them focused on past material the students should have learned. Unlike past lessons Megan used outside curriculum resources to create an open-ended task for her students to participate in during class. Megan specifically asked for the help of the researcher in choosing an activity from the

Interactive Mathematics Program (IMP) Year 2 curriculum (Fendel, Resek, Apler, & Fraser, 1998)[12]. She chose this particular curriculum resource because she had used activities from it in her senior year field experience and she liked the tasks it provided. Figure 14 displays the anticipation map for this lesson.

12 For further discussion of the role of the researcher in this study see Chapter 3.

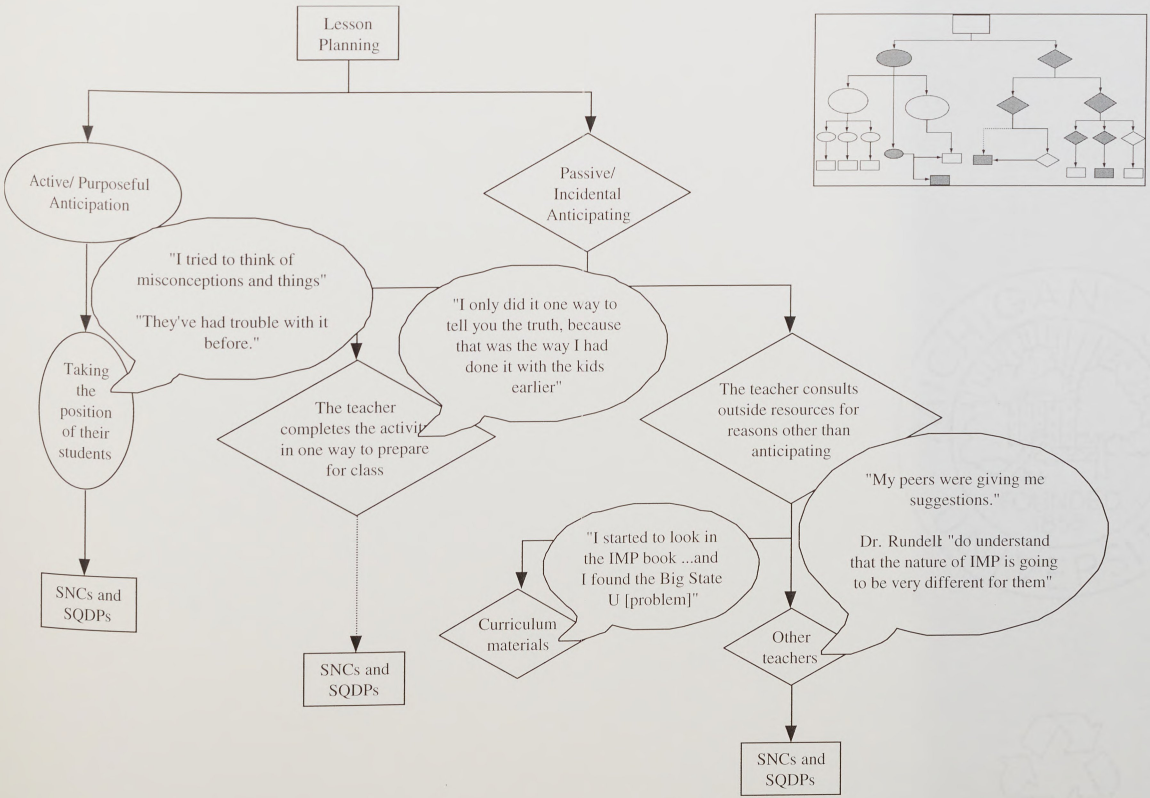

Figure 14. Cool Stuff Lesson 1 Anticipation Map

The right, passive/incidental, side of Figure 14 represents that Megan received feedback from other teachers about her lesson, in this case other interns in her methods course and Dr. Rundell, the methods course instructor. Megan shared some of her original activity ideas with two interns in the methods course during a case stories activity[13]. The other two interns recommended adding some scaffolding to the original activity because they felt it might be too open-ended for students who were used to lecture and note taking. One of the interns also suggested that Megan complete the task herself before teaching it, which she eventually did. In addition to consulting these resources Megan stated that she talked with Mrs. Starns before teaching the lesson.

Although Megan selected the task from the curriculum there is some question as to whether she consulted the accompanying teacher materials for the activity. This supposition is based on the fact that in her lesson plan she identified an incorrect final answer based on incorrect arithmetic even though the correct one was given in the teacher materials. Figure 15 shows Megan's own work to find the solution, which she corrected[14].

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13 See Hughes, Smith, Boston, and Hogel (2008) for further discussion of case stories.

14 After completing the lesson post-interview, the reseracher drew Megan's attention to the fact that the solution was (250, 250). She made this change to her work prior to supplying me with a copy, as can be seen in Figure 5.4.

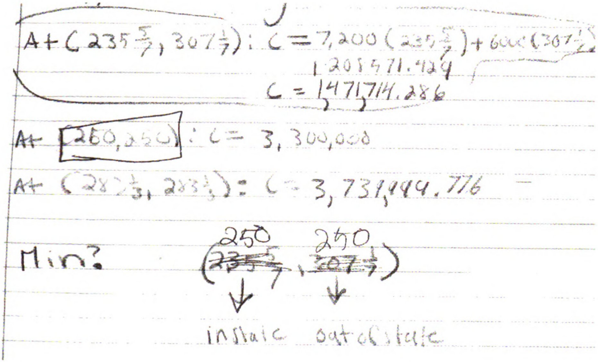
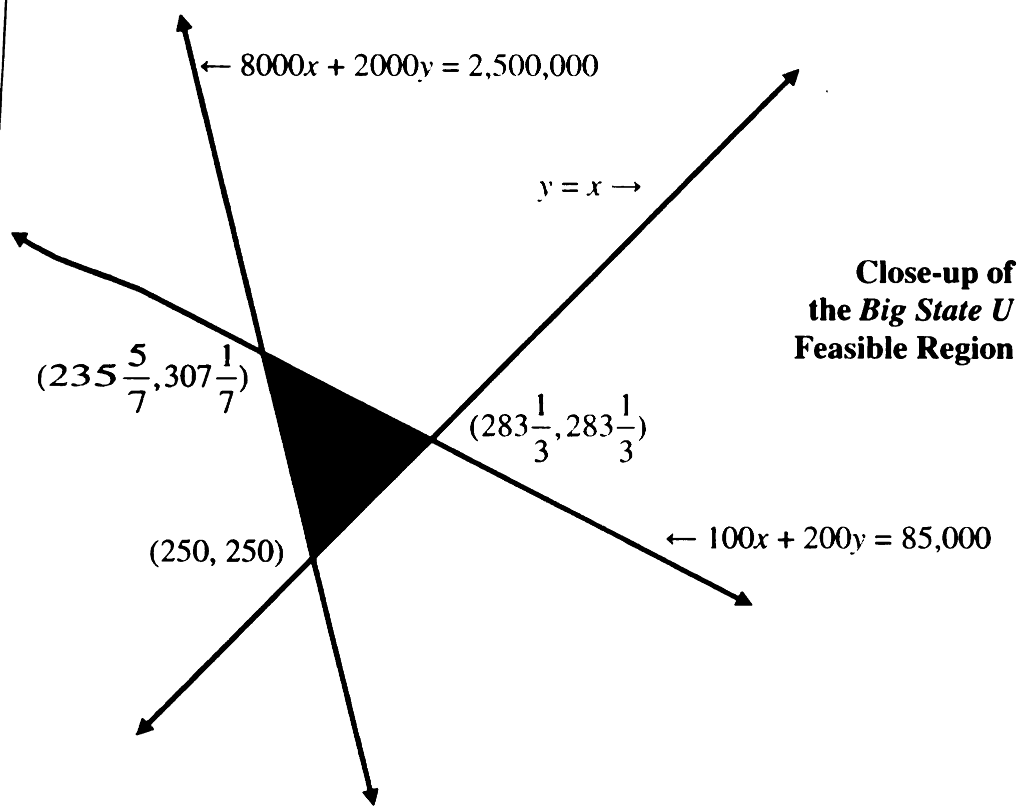


Figure 15. A Handwritten Portion of the Cool Stuff 1 Lesson Plan Showing Megan's Original Solution

Figure 16 shows a recreated portion of a page from the teacher manual with the correct solution highlighted by a rectangle at the bottom of the page.



- ***The details of the reasoning***

In presenting the problem, students should review how they sketched the graph, including how they knew which point minimized the cost and how they got its coordinates.

In explaining how they identified the point, students should use the "family of parallel lines" idea, in which the combinations of in-state students and out-of-state students that give any particular cost form a straight line, which "slides" when the cost is changed.

Students need to choose the "minimum" of this family of parallel lines. If they sketch one of these lines (for example, $7200x + 6000y = 1{,}440{,}000$), they will see the general direction of the lines in the family. (This is the dashed line in the first diagram.)

Students should see that the cost goes up as the line moves up and to the right, and so the minimum is at the point (250, 250).

Figure 16. A Recreation of a Page from Teacher Manual of IMP (Fendel, Resek, Apler, & Fraser, 1998)

Due to this evidence, the anticipated SMRs were not attributed to using the curriculum. Megan also indicated that she only completed the task herself in one way.

The left, active/purposeful, side of Figure 14 represents the fact that Megan chose to anticipate SMRs as a part of her lesson planning practices in preparing this lesson. Megan indicated in the pre-lesson interview that using the lesson plan template (which was required for the Cool Stuff assignments) and her past experiences with the students impacted her practice of anticipating. "The lesson plan template helps a lot because it really gets you through the process and I tried to think of misconceptions and things. I didn't research them a lot, but we had been going through things with the students so I had already thought of misconceptions that might come up" [Cool Stuff 1 Pre-Interview, October, 2008].

One of the student responses that Megan anticipated for this lesson dealt more with the structure of the activity than the content. Megan predicted that students might struggle with participating in a different kind of mathematical activity since they were so used to lecture and note taking.

> Because this is new to them, as soon as they come into the class I assume they are going to be having questions as to 'What are we doing? Why are we doing this?' It doesn't have to do with the task, but it does because it has to do with their motivation. [Cool Stuff 1 Pre-Interview, October, 2008]

This potential student response to the lesson was brought up in the conversation Megan had with the other interns as well as by Dr. Rundell in his feedback to Megan.

In addition to anticipating that students might be unsure about the structure of the lesson, Megan also anticipated SMRs related to the content. As in a previous lesson, she anticipated that students would potentially have difficulty knowing which side of an inequality to shade which could lead to errors in finding the feasible region. She also predicted that students would struggle to write equations and inequalities from the situation that was presented in the task because they were used to being given the equations and inequalities to work with.

> I imagine that they're going to have questions about how to set things up for the task. I mean everything is in words. So 'Where is the objective function?' 'Where are the constraints?' and how exactly do they set them up. [Cool Stuff 1 Pre-Interview, October, 2008]

Finally, Megan anticipated that students might not initially choose an appropriate scale for their graphs when graphing by hand. The next section describes Megan's anticipation of SMRs during the second set of lesson observations.

5.1.4 Observation 2

The second set of lesson observations and interviews took place over a two-week period in early November during the tenth and eleventh week of the school year. During these two weeks Megan was in the second guided lead teaching phase of the field experience, which meant that she was teaching all three sections of the Algebra 2 class. The schedule of observations was adjusted from the first observation to allow for more observations of Megan teaching and to eliminate the observation of class games and assessments. During the two weeks Megan followed Mrs. Starns' weekly schedule. Mrs. Starns and Megan together rearranged the order of the content in the textbook. This decision was based on Mrs. Starns' experience that students had trouble with quadratics and the fact that both had recently attended a county professional development workshop that emphasized the importance of students understanding this material. Table 5 shows the activities of the two weeks.

Table 5. *Schedule of Class Activities during Observation 2*

	Class Activities
Monday	Lesson 2.1 (Vertex and Intercept Form) Lecture and note taking with bridge picture packet
Tuesday	Lesson 2.2 (Vertex and Intercept Form cont.) Lecture and note taking with bridge picture packet
Wednesday	Lesson 2.3 (Converting between Standard and Intercept Form) Lecture and note taking with bridge picture packet
Monday	Lesson 2.4 (Factoring Quadratics of the Form $ax^2 + bx + c$) Lecture and note taking
Tuesday	Lesson 2.5 (Completing the Square) Lecture and note taking

During the first week Megan made use of a packet of pictures of bridges in her teaching. Mrs. Starns created this packet and gave each student a copy to serve as representations of parabolas in the real world for use in note taking during the week.

The content over the two weeks focused on quadratic equations and their various forms (e.g. standard, vertex, and intercept). During this set of observations Megan engaged in only passive/incidental anticipating during her lesson planning. Her potential resources for anticipating SMRs during this time consisted of her completion of the examples for the day and her conversations with Mrs. Starns. Figure 17 presents Megan's anticipation activities for this set of lessons.

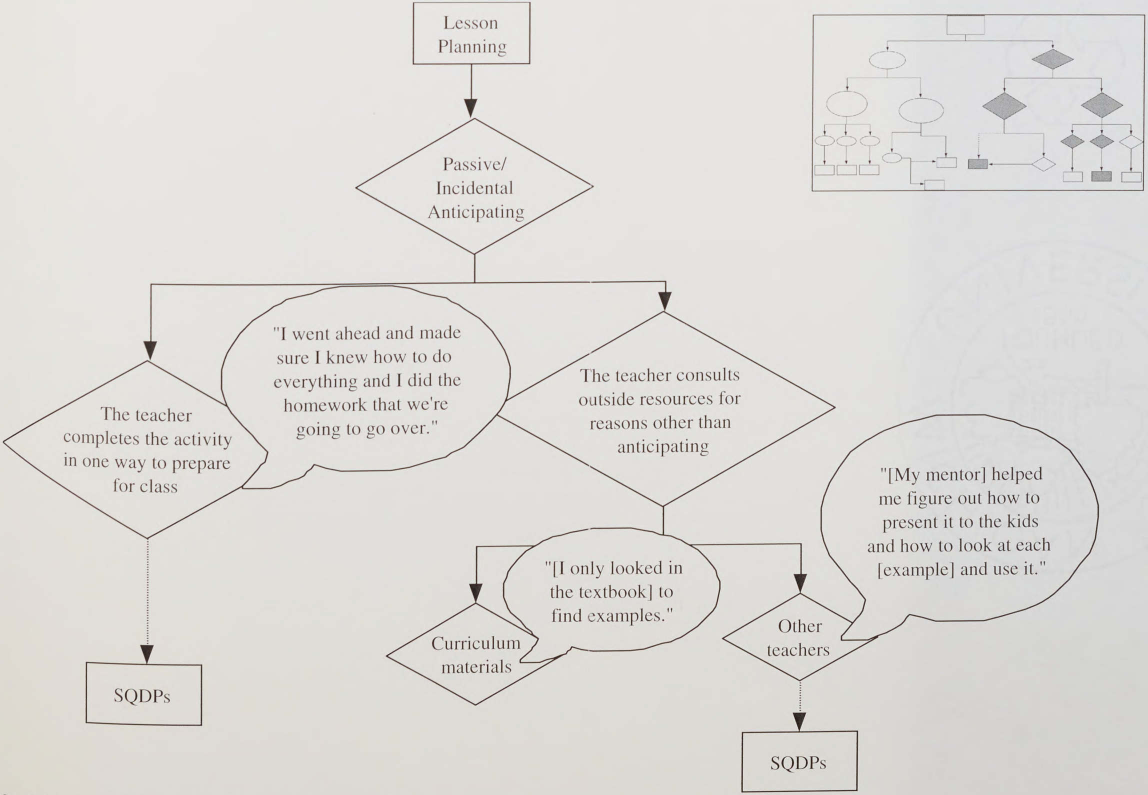


Figure 17. Anticipation Map for Lesson 2.1 through Lesson 2.5

As was a primary focus in the previous anticipation maps, this one shows that Megan's anticipation activities were passive/incidental.

Lesson 2.1 was the beginning of a new unit on quadratic functions and it focused on presenting two forms of quadratic equations, the vertex form and the intercept form. Throughout this series of lessons Megan used the packet of pictures of bridges created by Mrs. Starns as examples for the class. For this lesson Megan completed all of the examples herself, looked at her mentor teacher's notes from the previous year, and discussed the lesson with her, focusing on how to be more concise in her presentation. Megan anticipated that students would have difficulty knowing what the focus and directrix were, understanding what the variable *a* represented in the equations, and confusing the forms of the equation. Figure 17 shows that Megan completed the examples herself and talking with her teacher, in an effort to gain ideas about how to be more precise, potentially led to the SMRs that she anticipated.

In Lesson 2.2 students continued taking notes using the bridge examples in the packet and finding the equations of the parabolas they created. Megan again completed all of the examples and consulted her mentor teacher before teaching this lesson about how to present the examples though when asked she said, "we didn't solve them ...we verbally did it" [Lesson 2.2 Pre-Interview, November, 2008]. One of the examples called on the students to measure using a ruler and convert to actual measures which Megan anticipated might be difficult for them. "You're given the height, but you're not given the height from where the vertex is to where the cable is, so we have to use ratios and they might get a little confused" [Lesson 2.2 Pre-Interview, November, 2008]. Additionally, Megan thought that the students might struggle to recall the steps in writing the equations they learned the previous day.

Lesson 2.3 was the final lesson focusing on the vertex and intercept forms of quadratic equations. In this lesson Megan introduced "boxing" as a method for converting between the standard form and intercept form of a quadratic equation. (The boxing method uses an area model to help students multiply binomials.) Figure 18 is a portion of Megan's lesson plan that shows the example she used to present the boxing method.

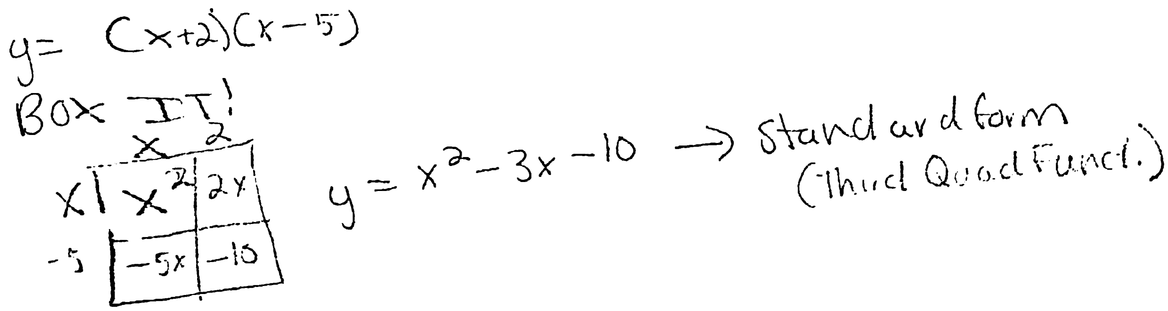


Figure 18. A Handwritten Portion of Lesson 2.3 Showing Megan's "Boxing" Example

When preparing this lesson Megan completed most of the examples ahead of time and her mentor teacher explained the boxing method to her. She anticipated that students might struggle with the boxing method because they had not seen it in a while and that they might have some difficulty identifying the correct factor pairs for the coefficient of the x term when boxing. Megan also thought that students might ask "Why would we have to switch from standard form to intercept form?" [Lesson 2.3 Pre-Interview, November, 2008].

In Lesson 2.4 students again applied the boxing method to factor quadratic expressions, this time with a leading coefficient other than one. Based on her own work doing the examples she found in the textbook and her conversations with Mrs. Starns, Megan anticipated several SQDPs. First, Megan explained that Mrs. Starns told her that students have a difficult time knowing to make use of the zero product property when solving quadratic equations. Figure 19 represents one of the examples Megan presented in the lesson in which students needed to recall this property to solve after the quadratic equation had been factored.

Ex. 1

$(5x + 7)(x + 2) = 0$

$5x + 7 = 0$

$x + 2 = 0$

Solving:

$x = -7/5$ and $x = -2$

Figure 19. Example of Making Use of the Zero Product Property from Lesson 2.4

Megan also anticipated that students would struggle with using the boxing method when the variable *a* in the standard quadratic equation was a value other than one. Finally, Megan was concerned that students might not remember the steps in the boxing method that they were reintroduced to the previous week. "When I [use] the box, maybe they will forget steps" [Lesson 2.4 Pre-Interview, November, 2008].

The final lesson in the second set of observations was of Lesson 2.5. In Lesson 2.5 Megan showed the students how to complete the square using the boxing method. She stated that she talked with her mentor teacher about how to teach completing the square in this way, completed the task herself, and that she used the textbook as a resource to find examples. She anticipated that students would ask questions about a process used in completing the square, specifically, "Why do you add and subtract the number?" [Lesson

2.5 Pre-Interview, November, 2008]. The next section describes Megan's anticipating in the second Cool Stuff lesson assignment.

5.1.5 Cool Stuff 2

The second Cool Stuff lesson took place in late November. As with the first Cool Stuff lesson, Megan participated in both active/purposeful and passive/incidental anticipating in planning this lesson. Similar to the first Cool Stuff lesson, Megan used this assignment to review some of the past content in the chapter for an upcoming test. She also added a portion of new content to the lesson, specifically finding the discriminant of a quadratic function. Megan and her mentor teacher created the activity for Cool Stuff 2 together and used video of a recent school football game as the context for the activity. In the activity students watched several clips of the football game in which the football created parabolas as it traveled through the air. Groups of students were then asked to write the equations for the parabolas created by the football that they viewed in the video. Prior to watching the football video Megan presented notes to the class on finding and using the discriminant of a quadratic equation. Figure 20 presents Megan's anticipation activities for this lesson.

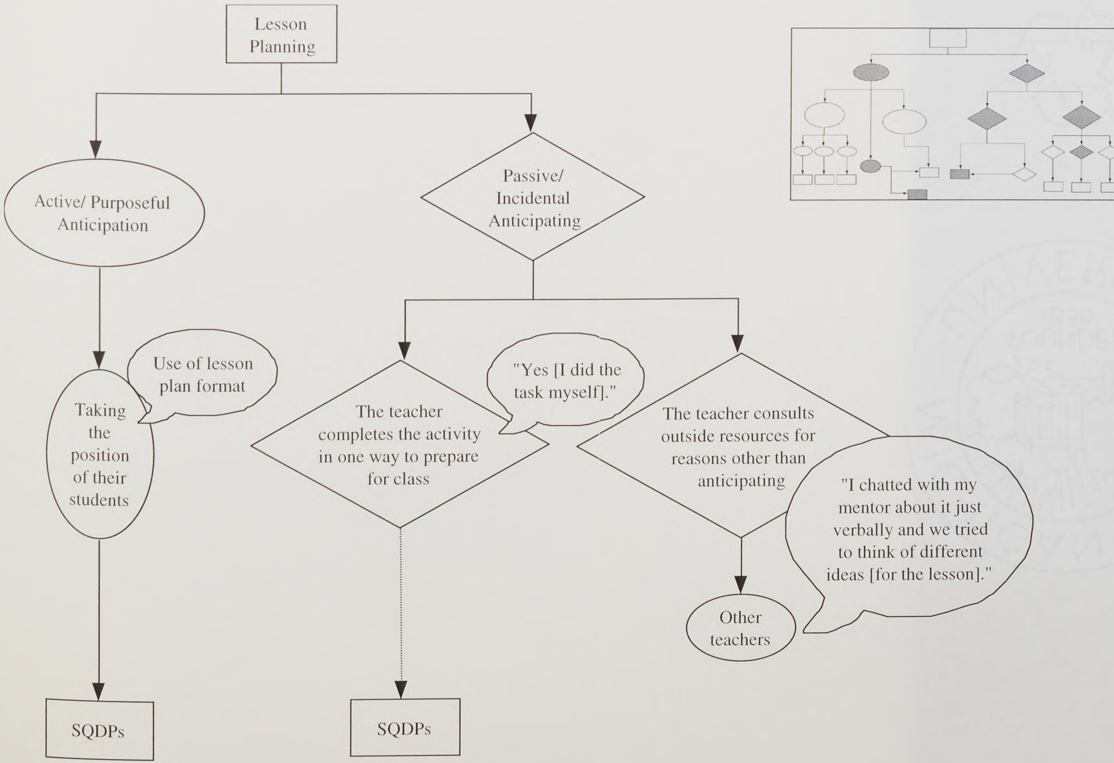


Figure 20. Anticipation Map for Cool Stuff 2 Lesson

The passive/incidental side of Figure 20 indicates that the only resource that Megan consulted in planning the Cool Stuff 2 lesson was her mentor teacher and only to discuss ideas for the activity. In addition, she completed the task herself, which potentially led her to consider some SMRs. The use of the lesson plan format is included in the active/purposeful side of Figure 20 because it specifically calls on the teacher to anticipate student thinking and questions. In this section of her written lesson plan Megan included several SQDPs.

In planning this lesson Megan anticipated only SQDPs. The first was that students would struggle with the meaning of the variable *a* in both vertex and intercept form, something she also anticipated in Lesson 2.1. Megan also considered that the students might have trouble performing the procedures for completing the square using the boxing method that they had learned in a previous lesson. In addition, Megan expected that students would have a difficult time finding the initial location and total distance traveled by the football and finding the maximum height of the football from the video. Megan also included in her lesson plan a series of student questions she thought might arise: Which form do I start with? What is *a*? How do I get Quad Form on my calculator? What are the directions? Do I need to write out the vertex? Do I need to write out *p* and *q*? Finally, similar to her Cool Stuff 1 lesson, Megan included in her lesson plan that students might struggle to engage with the mathematics in ways other than those they were used to in this lesson. "Students may have trouble answering the group discussion questions. They are deep thinking questions that students are only used to doing in the reading packets.[15]" The next section describes Megan's practices of anticipating during the third and final set of observations.

5.1.6 Observation 3

The third set of lesson observations and interviews took place in the second week of December. During this time Megan was only teaching her Focus class. During the observations Megan followed the sections in the sequence prescribed by the textbook. Table 6 shows the class activities during the observation.

Table 6. *Schedule of Class Activities during Observation 3*

	Class Activities
Monday	Lesson 3.1 (Graphing Square Root and Cube Root Functions) Lecture and note taking
Tuesday	Lesson 3.2 (Statistics and Statistics Graphs) Lecture and note taking
Wednesday	Lesson 3.3 Students complete review worksheet individually

Only the first two lessons, Lesson 3.1 and 3.2, were analyzed for the nature of anticipating because Megan did not teach anything on Wednesday of that week and thus did not prepare a lesson plan. In preparing the two lessons Megan only participated in passive/incidental anticipating and drew on her mentor teacher, her own completion of the tasks, and considerations about student reactions as resources. Figure 21 displays the anticipation map for these two lessons.

[15] Solutions to problems from the reading packet were always presented to the students by Megan or Mrs. Starns.

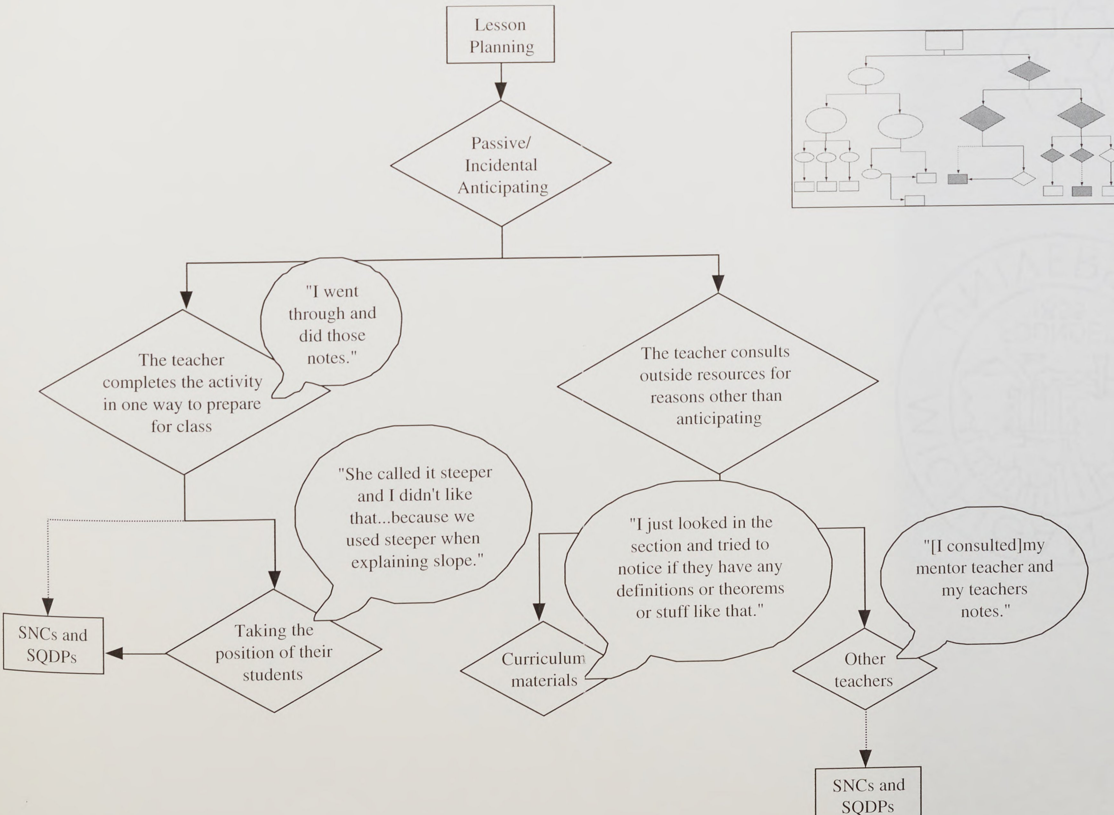


Figure 21. Anticipation Map for Lesson 3.1 and 3.2

Figure 21 illustrates that as with many of the past lessons Megan's anticipation of SMRs fell on the passive/incidental side of the anticipation framework. However, in completing the activity to prepare for Lesson 3.1 Megan did take the position of her students in anticipating a particular SQDP. Lesson 3.1 focused on graphing square root and cube root functions. Megan anticipated that the students might have difficulty with some of the language her mentor teacher suggested using to describe the changes to the graphs. Mrs. Starns described the cubic functions as becoming "steeper" as the equation changed. Megan was concerned that this might be confusing for students since they had used similar language to describe the graphs of quadratic equations and she chose to describe this differently in her teaching. Figure 22 is an example from Megan's notes that shows her use of the phrases "further from" and "closer to" opposed to "steeper" or "less steep" to describe the differences of the graphs of a cubic equation.

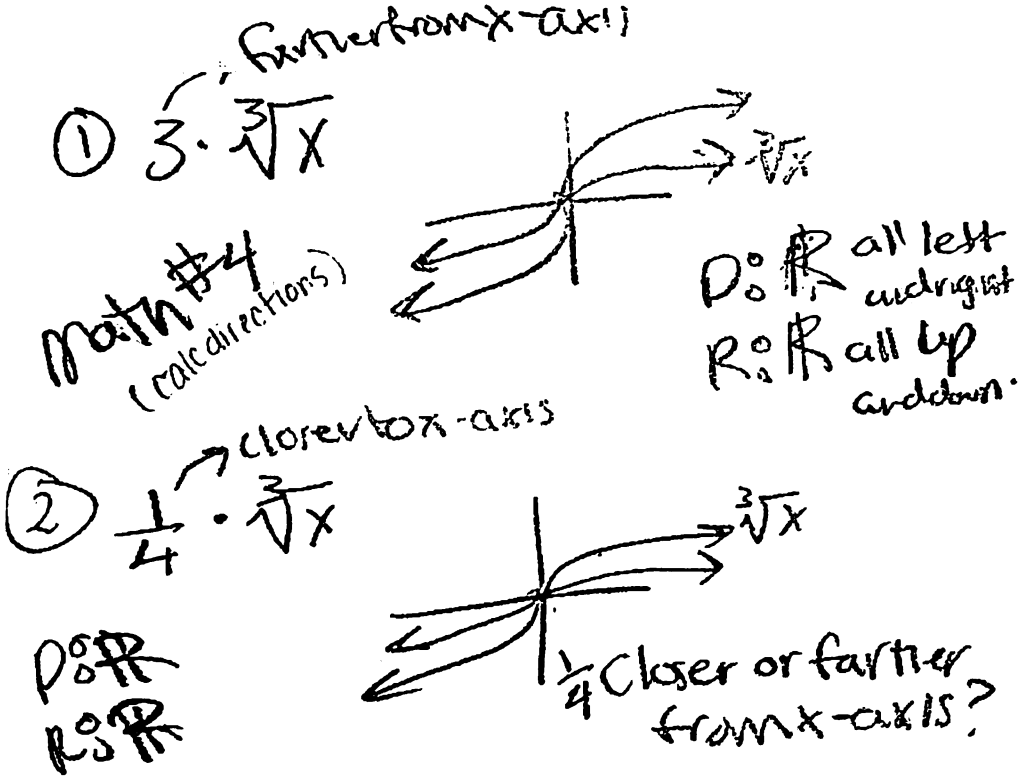


Figure 22. A Handwritten Portion of Lesson Plan 3.1 Illustrating Megan's Language Choice

This instance on anticipating occurred at a deeper level than much of the past anticipation which focused on whether students would remembers procedures. In this case, Megan reflected on students past experiences with the mathematics in on order to consider their possible reactions to her current presentation.

For Lesson 3.1 Megan used a worksheet created by her mentor teacher to teach the lesson. She completed the worksheet herself before teaching the class. The class worked through the problems on the worksheet together and Megan pointed out how various changes to the square root and cube root equations impacted the graph of the equations. This was the first instance during data collection in which the textbook pointed out a possible student difficulty (Figure 23).

! COMMON ERROR
EXERCISES 22–39 Students may confuse the horizontal and vertical shifts or shift horizontally in the wrong direction. Refer these students to the box on page 431 and to Examples 2 and 3 on page 432.

Figure 23. Student Difficulty Presented in Class Text

Because Megan did not make use of the textbook to create her examples, and because she did not mention this as a potential SQDP, it is possible she did not even see this hint for teachers in the textbook. In addition to noticing changes to the graph, students were also expected to find the domain and range of the functions and Megan anticipated that they would have difficulty understanding what they were, visually seeing how to find them, and remembering which was which.

> For the cube root function the domain and range is all real numbers, so they are good to go on that. But on the [square root] part they're probably going to have questions on domain and range. The domain is the x's and range is the y's, so they'll probably get confused on that... I think looking at it, sometimes visually, they have trouble knowing that even though the x's go this way, they actually run this way, even though they're on this axis. So when they look at it they get confused, visually. [Lesson 3.1 Pre-Interview, December, 2008]

She also expected that students might struggle to recall how to enter cube root functions into their calculators.

Finally, Lesson 3.2 focused on reading and creating box and whisker plots. Megan did not talk with her mentor teacher about this lesson before she taught it and in fact wrote her lesson plan while watching the mentor teacher teach the material to the other Algebra 2 class first period. "My mentor and I didn't have time to discuss this so I just recorded her notes that she did during first hour" [Lesson 3.2 Pre-Interview, December, 2008]. Despite not preparing a lesson plan in advance of the school day, Megan did state that she looked over the textbook to figure out how this lesson connected to the previous lesson. Again in this instance the textbook presented a common error that students might make, but Megan did not reference this error in talking about possible SMRs.

For Lesson 3.2 Megan anticipated both SQDPs and SNCs. The SNC that she anticipated was that students might think that the middle line of the box and whisker plot represented the mean instead of the median. "I think that in the box plot some people think that the middle line is the average when it's really the median" [Lesson 3.2 Pre-Interview, December, 2008]. In considering the possible questions of difficulties that her students might encounter in this lesson, Megan stated that she thought they might have a hard time using the calculator to create a box and whisker plot. She also thought that students might confuse median and mode and that they might not realize that the range of a set of data is a difference, and therefore not a negative value. The next section presents Megan's anticipation practices in a lesson that she prepared to teach near the completion of data collection.

5.1.7 In-Depth Interview 2

The final interview with Megan took place during the third week of December. She brought a lesson plan to the interview that she planned to teach that week, which focused on exponential growth functions. Her anticipation of SMRs for this lesson was similar to what was found in previous lesson; it was passive/incidental and relied mainly on her own completion of the examples. For this lesson Megan planned to lecture as the students used their calculators and took notes on the examples she presented. Figure 24 displays Megan's anticipation activities for this final lesson.

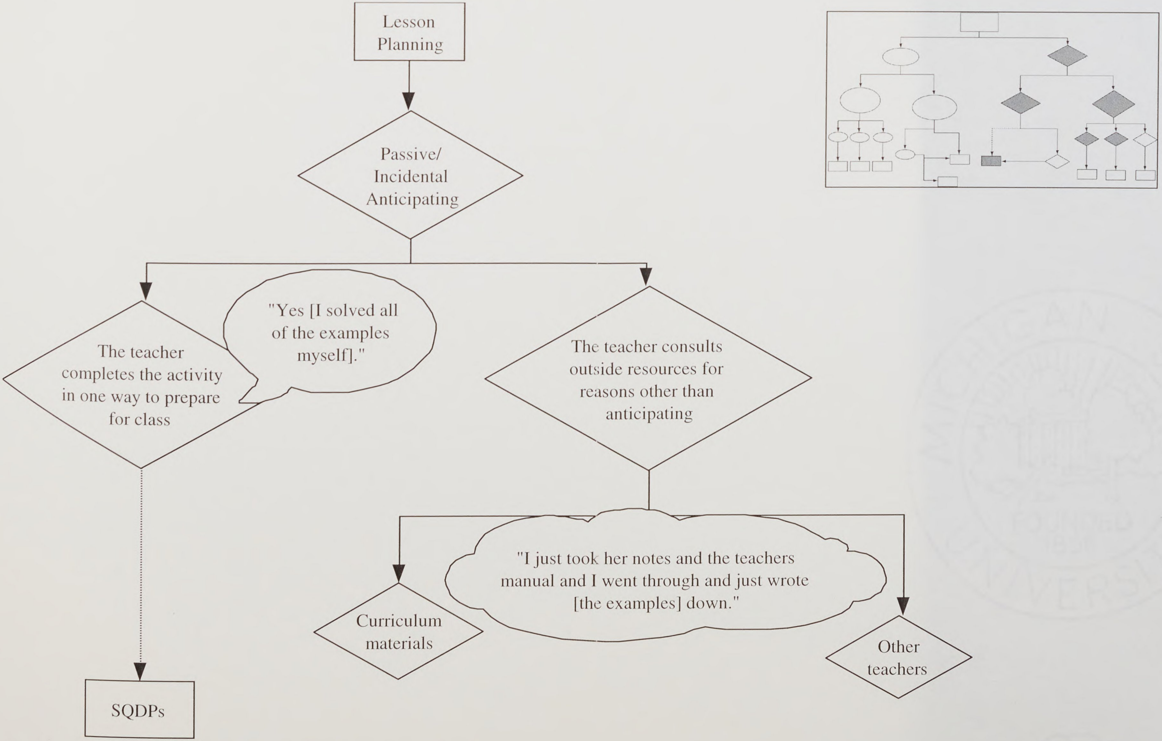


Figure 24. Anticipation Map for Lesson Discussed during In-Depth Interview 2

Figure 24 displays that, similar to previous lessons, Megan used her mentor teachers' notes from past years and the textbook to choose her examples and completed all of the examples herself. However, neither the use of the textbook nor her mentor teacher's notes led her to anticipate any SMRs. For this lesson Megan anticipated that the students might ask a particular question about two of her examples shown in Figure 25.

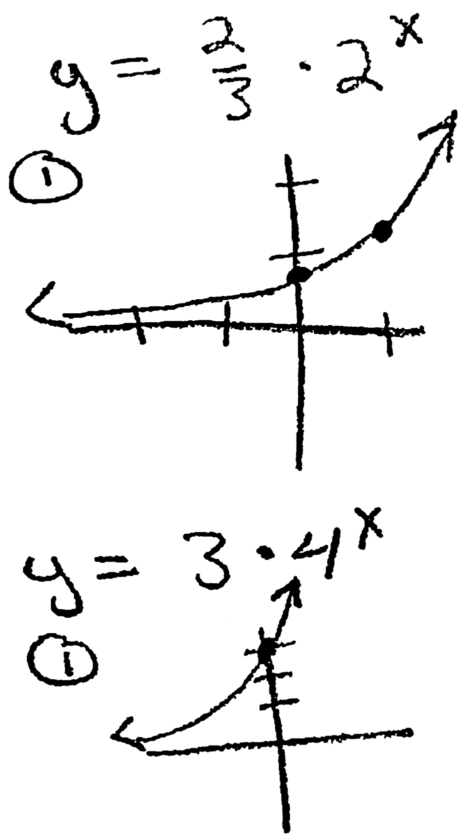


Figure 25. A Handwritten Portion of In-Depth Interview 2 Lesson Plan

"They might ask me about this fraction in front here and the number here and how that [difference] impacts exponential growth" [In-Depth Interview 2, December, 2008]. She also thought that students might struggle with knowing which way to shift the exponential graph based on the signs of the constants in the equation. The next section summarizes the findings related to the nature of Megan's practices of anticipating SMRs in her lesson planning.

5.1.8 Summary of Anticipation

The content of Megan's anticipated SMRs varied from lesson to lesson over the semester. In ten of the thirteen lessons, Megan anticipated that students would struggle to recall past content learned in the class and which was needed for the current class. This often focused on "remembering the steps" that had been presented to them. In nine of the thirteen lessons, she anticipated that students would have difficulty with the new materials being presented that day. When she anticipated SMRs around new content, it dealt primarily with students' understanding of the material that she herself was presenting. For example, in Lesson 2.4 when Megan was teaching the students to use the boxing method to factor quadratic expressions with a non-zero leading coefficient, she was concerned that students would struggle to know what to do with the leading coefficient, even though this was the focus of her lesson. The content of what Megan anticipated also focused mostly on student questions or difficult points (SQDPs) and to a much lesser degree student naïve conceptions (SNC). Noticeably absent from the list of what was anticipated is multiple student solutions strategies (SSS), which was included in the anticipating framework. Possible reasons for this absence will be discussed in the second half of this chapter.

The previous findings also shed light on the resources that Megan made use of in order to anticipate. Most of the anticipating that she practiced was passive/incidental and came from her own work of completing the mathematical examples in her way. While

Megan often made use of the class textbook she did so exclusively for the purpose of finding examples, definitions, and homework and quiz problems. Recall that the textbook on two occasions offered possible SQDPs and that Megan did not report either of these when discussing the anticipated SMRs for the lesson. On only two instances did Megan look outside of the class curriculum to find activities, for the Election Project and to find a task for Cool Stuff 1. Megan also made frequent use of her mentor teacher as a resource for teaching. Evidence indicated that these interactions rarely included the discussion or sharing of possible SMRs. Table 7 summarizes the resources that Megan used to anticipate in each lessons as well as what she anticipated.

Table 7. *Summary of Anticipation Activity*

	Lessons												
	ID1	1.1	1.4	CS1	2.1	2.2	2.3	2.4	2.5	CS2	3.1	3.2	ID2
Active/Purposeful Anticipating													
The teacher consults outside resources in order to anticipate													
▪ Curriculum materials													
▪ Other teachers													
▪ Research literature													
Completes activity in more than one way													
Takes position of students	√			√						√			
Passive/Incidental Anticipating													
The teacher consults outside resources for reasons other than anticipating													
▪ Curriculum materials	x		x	x				x	x			x	x
▪ Other teachers	x	√	○	√	○	○	○	○	○	x	○	x	x
▪ Research literature													
Completes activity in one way	○	○	○	○	○	○	○	○	○	○	○		○
Takes position of students		√	√								√		
Outcomes of Anticipating													
SSS													
SNC			●									●	
SQDP	●	●	●	●	●	●	●	●	●	●	●	●	●

Note: ID1 and ID 2 represent In-Depth Interview 1 and 2 respectively and CS1 and CS2 represent Cool Stuff 1 and Cool Stuff 2 respectively.

The checkmarks in the table indicate instances in which there is evidence that a resource was used to anticipate, even though it may not have been the original purpose of consulting the resource. The open circles indicate that a resource was consulted, but that there is not sufficient evidence to be sure that it contributed to anticipating or that it did not. The x's represent evidence that a particular resource did not contribute to anticipating in any way. The table shows that purposeful anticipating occurred only when required for a university lesson (as in Cool Stuff 1 and 2) or in one of Megan's early lesson plans (In-Depth Lesson 1). Additionally, all of the instances of both taking the position of students or interacting with other teachers (mainly her mentor teacher) that led to anticipating, are found earlier in the semester. Despite this lack of active/purposeful anticipating and relatively infrequent use of resources to anticipate, the table also shows that Megan was able to anticipate some kind of SMR for each lesson that she taught, although they were often focused on students remembering procedures.

Another method of summarizing the results is presented in Figure 26. This figure shows the entire anticipation framework for each lesson, or set of lessons, with the shaded areas representing the activities in which Megan participated.

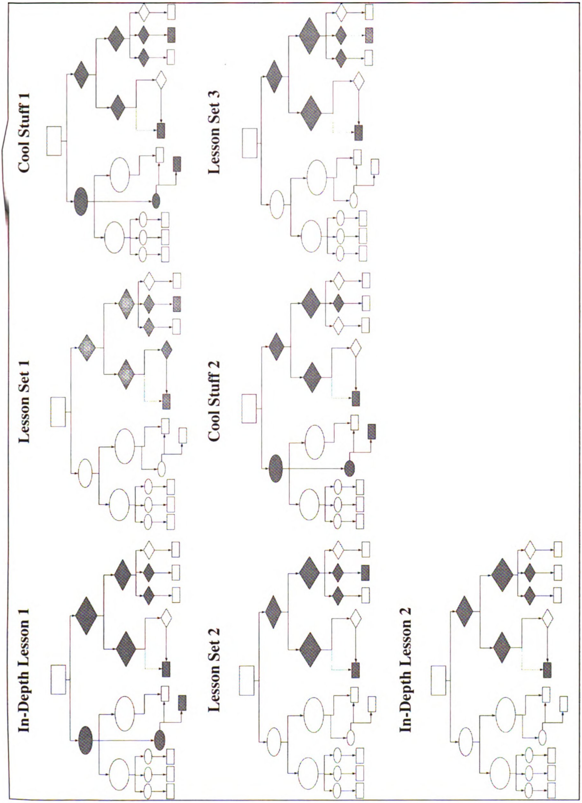


Figure 26. Collection of Anticipation Maps Representing Megan's Activities over the First Semester

Figure 26 again highlights the relative infrequency of Megan's active/purposeful anticipation activities, or those on the left of the anticipation framework. Additionally, the farthest right portion of each map shows Megan's lack of using research literature or teaching journals in any way during her field experience. Her use of resources overall was limited to finding out what content to teach in class and to picking out examples and problems to make use of to teach that content.

The next section takes a different look at Megan's anticipating practices by describing two classroom interactions that took place around the SMRs that Megan anticipated. While Megan's anticipation of SMRs prior to teaching was the primary focus of this research question, these two instances provide insight into how Megan made use of what she anticipated. These mini-cases are intended to illustrate two possibilities of what could happen when an intern, or any teacher, anticipates SMRs during lesson planning.

5.1.9 Mini-Cases

The following two mini-cases represent lessons in which Megan anticipated a specific student difficulty and the actions that she took based on what she anticipated. The first mini-case characterizes a situation in which Megan anticipated a student difficulty and made an attempt to consider ways to address this particular difficulty but without success. The second mini-case illustrates an example of Megan making a conscious effort to address the difficulty she anticipated in her teaching, to an arguable degree of success.

The first mini-case comes from Lesson 1.4 and focuses on Megan's anticipation of student difficulties related to plotting points in three dimensions. In the interview that took place prior to teaching her lesson Megan anticipated that students would have difficulty visualizing three dimensions as they learned to plot points on three axes. She stated that "when they're graphing things in three dimension[s] sometimes the kids have trouble visually seeing it" [Lesson 1.4 Pre-Interview, October, 2008]. She went on to explain why she thought visualizing might be particularly difficult in three dimensions:

> I think they will be confused about the z-axis. I think that when we're graphing, it's sort of different [than in two dimensions]. Because you would automatically think if you had a three-dimensional graph that you would go over two, up three. But then you have to go on your z-axis. And you would think that you would go up to that line and then count up. [Lesson 1.4 Pre-Interview, October, 2008].

Megan indicated that she too had had trouble in the past visualizing in three dimensions. She stated that she thought students might have questions about plotting z, specifically "how do you get z in the right spot?"

In addition to the difficulty with the content Megan anticipated, the fact that students had struggled with other content earlier in the week prompted Megan to further consider how she would present the material. "I think if I had started Monday with simpler examples they would have grasped it more, quicker" [Lesson 1.4 Pre-Interview, October, 2008]. Based on her desire to make her teaching and examples simpler she talked with her mentor teacher to get some ideas. "From previous lessons I wanted to make sure that I talked to my mentor teacher before I taught it to see if there was a way to simplify things or a better way to explain them" [Lesson 1.4 Pre-Interview, October, 2008]. Megan talked with her mentor and Mrs. Starns gave her an idea for teaching which Megan related to me in the interview before she taught. "So we try to say 'start at the origin, don't pick up your pencil, and then you do the x, and then you do they y, and then you do the z.'" Megan included this technique in her lesson plan by writing next to her example:

Don't pick up
pencil

Figure 27. Megan's Handwritten Teaching Note from Lesson Plan 1.4

In addition to talking with her mentor teacher before school Megan made a last minute change to her lesson plan in order to simplify her first example. "Well the first one I'm going to do I'm changing to (2, 2, 2)" [Lesson 1.4 Pre-Interview, October, 2008]. When pressed she indicated that this example was simpler than the other one she had chosen, (3, -1, -5), because all of the values were positive. She planned to follow the first example with another example which had some negative values. Figure 28 shows a portion of Megan's lesson plan.

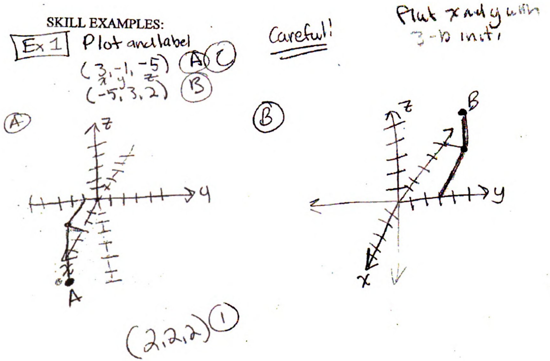


Figure 28. A Handwritten Portion of Megan's Lesson Plan from Lesson 1.4

It can be seen from her lesson plan that she did not plot her new example, (2, 2, 2), before she taught. When asked about the note on the lesson plan that said "Careful!" Megan stated that was in relation to the graphing and was a reminder to her to "just to tell the kids 'you have to be careful and you have to focus'" [Lesson 1.4 Pre-Interview, October, 2008]. Thus this was a note to herself to remind the students to be careful about their work, as opposed to a note in response to an anticipated SMR.

The activities in this lesson were much the same as others in this class, students came in and collected their work and Megan went over some of the homework questions from previous day and then began presenting notes to the students. She began the example portion of the notes with the new example that she added at the last minute. She wrote the following on the overhead projector:

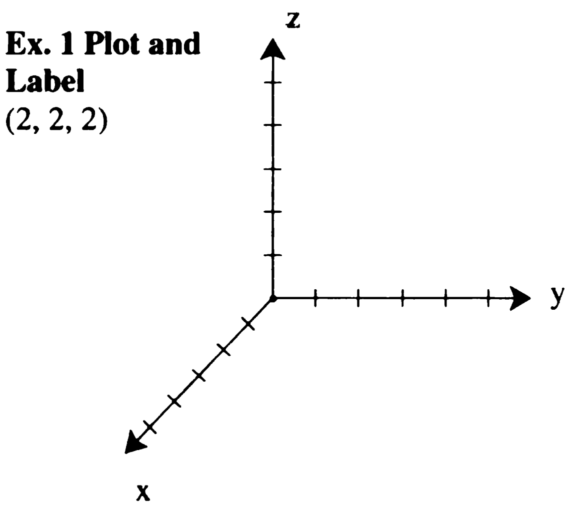


Figure 29. Representation of the Notes Megan Wrote on the Overhead Projector

As planned, she began by telling the students to "take your pencil and put it on the origin at (0, 0, 0). What ever you do don't lift up your pencil" [Lesson 1.4 Observation Field Notes, October, 2008]. She used her overhead marker to trace a path to plot the point as shown in the figures.

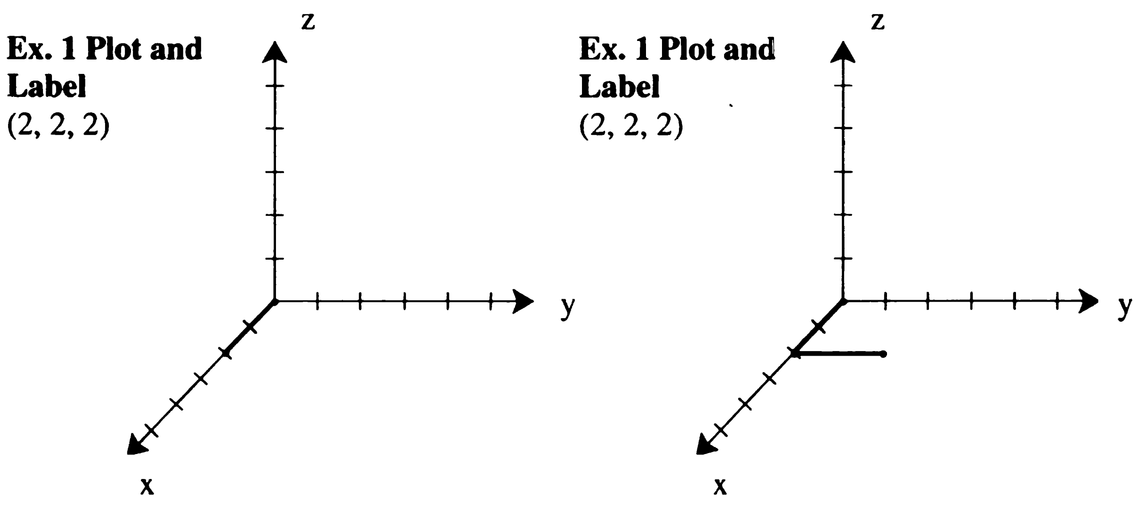


Figure 30. Representation of the Notes Megan Wrote on the Overhead Projector

When Megan arrived at the moment to plot the last dimension, the one she had anticipated that students would have difficulty visualizing, she drew the following:

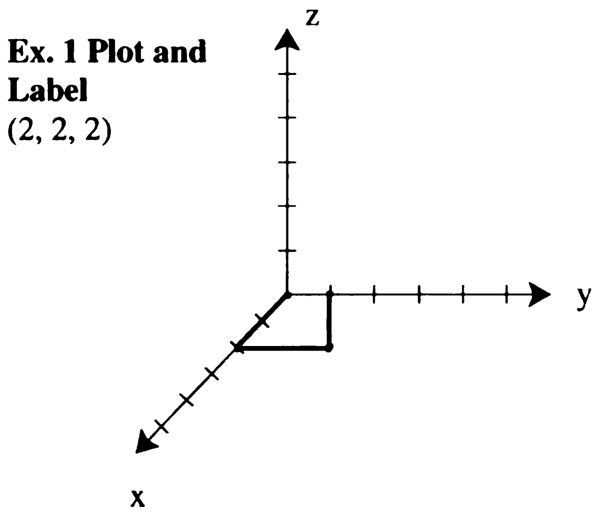


Figure 31. Representation of the Notes Megan Wrote on the Overhead Projector

After students finished copying her representation into their notes they began to call out questions and comments such as "you didn't graph on the z" and "you don't graph the other points?" Through discussion it became clear that the students think their pencils had "landed" on a point on the y-axis, which was not the correct location of the point. Megan attempted to explain where the point actually was but students did not appear to be convinced that it was not actually on the y-axis. After this example Megan went on to her next example plotting the point (3, -1, -5). As with the first example students began calling out questions "I thought you said you graphed the points regular?" "Where would the y be?" After she completed the two plotting points examples she went on to do three examples for the class involving graphing equations with three variables.

While reflecting during the interview after the lesson Megan stated that students "were a little confused," "had trouble understanding," and "had lots of questions" about plotting points in three-dimensions. She recognized that there were some difficulties with her first example, "that's probably something that didn't go so well...it ended up on the y-axis and it was really off the y-axis" [Lesson 1.4 Post-Interview, October, 2008]. She stated that she realized that some students were still struggling with plotting points and added that "they were a little freaked out at the beginning with just graphing the point. And like my mentor said, 'sometimes kids get it or sometimes kids don't.' So the ones that didn't, really didn't like not getting it" [Lesson 1.4 Post-Interview, October, 2008]. She notes she would not be sure if students had met her objective for plotting points until she looked over their homework the next day.

Megan did reference the specific example of plotting the point (2, 2, 2) when asked if anything about the lesson surprised her.

> I don't know if I graphed it wrong but when they graphed one of the points it looked wrong...It was just a little off and it sort of threw me and then it threw them. [Lesson 1.4 Post-Interview, October, 2008]

When asked what she would do differently on Monday based on what happened in class that day Megan said that she would probably go over a homework problem that asked the students to plot points in three dimensions. She did not indicate whether she would go over the example in a different way, although it seemed to be the norm in the class to model the same procedures in going over the homework problems that were modeled in the notes.

The preceding is a case of a preservice teacher anticipating a student difficulty that did occur, but not taking sufficient action in her lesson plan or teaching to address this potential difficulty. We see in this case that the only resource that she sought out for helping her deal with this anticipated difficulty was her mentor teacher. Although her mentor teacher was able to provide her advice for how to simplify her lecture, her advice did not help Megan address Megan's concern about the students' potential difficulty visualizing in three-dimensional space. Despite not receiving any ideas from her mentor teacher on her particular concern Megan did not seek out other methods for teaching the content specifically to help her address the difficulty she anticipated.

One possibility for finding an alternative method could have come from the class textbook. Megan indicated that she was aware that the text used a different method but did not explain her pedagogical reason for choosing her mentor teacher's method over this one. The textbook method lays the xy-plane on its side and then positions the z-axis perpendicular to the x- and y-axis through the origin as shown in Example 1 from the class text (Figure 32)

EXAMPLE 1 ***Plotting Points in Three Dimensions***

Plot the ordered triple in a three-dimensional coordinate system.

a. $(-5, 3, 4)$ **b.** $(3, -4, -2)$

SOLUTION

a. To plot $(-5, 3, 4)$, it helps to first find the point $(-5, 3)$ in the xy-plane. The point $(-5, 3, 4)$ lies four units above.

b. To plot $(3, -4, -2)$, find the $(3, -4)$ in the xy-plane. The $(3, -4, -2)$ lies two units bt

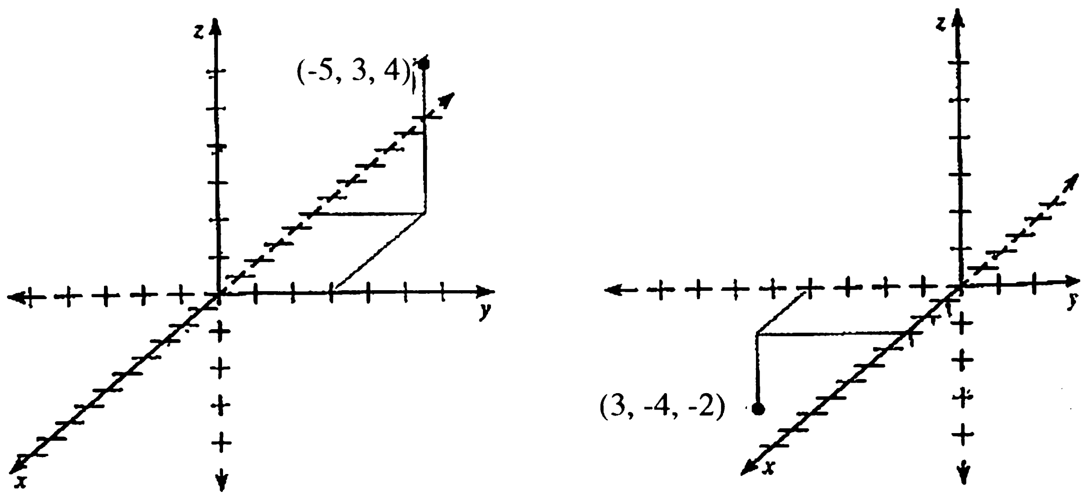


Figure 32. Portion of the Class Text Presenting Plotting Points in Three Dimensions

While this is the same representation of the three-dimensional axes used by Megan, the way that the text book describes plotting the first two coordinates in the xy-plane and then moving *up* or *down* on the z-axis is different. Megan did not overtly orient the z-axis relative to the xy-plane in the same way that text book did which may have part of what caused confusion for the students.

When reflecting on the lesson in the post-lesson interview Megan indicated that she realized students had struggled with plotting a point in three dimensions as she anticipated they would. She did not connect the fact that she did not do the first example, (2, 2, 2), in advance to the fact that it did not play out as she would have wanted or that failing to do so may have added to the students' confusion.

She also did not reflect that perhaps she could have sought out a different method for teaching the content and her mentor teacher's feedback after the lesson that this is something that "either you get it or you don't" would not have prompted her to look further either. Finally, there was no evidence that Megan planned to demonstrate plotting points in three dimensions differently the next day when she went over an example of this from the homework.

The Plan, Teach, Reflect cycle that is integral to the Methods course includes reflecting on areas of growth after teaching a lesson. In this case this would have included Megan thinking of a different way to present plotting points in three dimensions for the next days homework review since she thought that some of the students were still struggling with the concept. Although a formal write up of this kind is only required on two occasions during the semester, the habit of reflecting in this way was also advocated in the previous year methods courses. This lack of revision to her original teaching plan for the next day indicates that not only was Megan not seeking additional resources to help her deal with anticipated student difficulties, but also that she was not consistently reflecting on how to make her teaching better.

A second case that illustrated an outcome of anticipation was exhibited during an observation in early November. On this particular day Megan was teaching the students to factor trinomials using what Megan and Mrs. Starns referred to as the "boxing" method. This method made use of an area model to factor polynomials. The students were familiar with the model because they had used it to multiply binomials earlier in the year. Figure 33 shows an example of a completed box.

Example: $x^2 + 11x + 24 = 0$

	x	3
x	x^2	$3x$
8	$8x$	24

Figure 33. A "Box" Model Showing the Factorization of $x^2 + 11x + 24 = 0$

Before teaching the class Megan explained that her mentor teacher told her that the students would have difficulty choosing factors of the constant term that would sum to be the coefficient of the x term.

> Well they have trouble because they have x squared which goes here, and [they] have negative ten. But finding that when you add these together that they come up with this middle number, that can be really hard. Because sometimes you might end up [with] a negative here and a positive here but then it doesn't work so maybe you have to flip flop them. [Lesson 2.3 Pre-Interview, November, 2008]

Although she was aware of this difficulty she did not address it anywhere in her written lessons plans.

Despite not addressing this anticipated student difficulty in her lesson plans, Megan's actions during her teaching of the lesson indicated that she did attempt to attend to the potential difficulty. This occurred when Megan presented a particular example during the note taking portion of the lesson. Megan began by writing an equation on the overhead, drawing a part of the box that would be used, and telling the students that there were some things they could fill in just from looking at the equation, as represented in Figure 34.

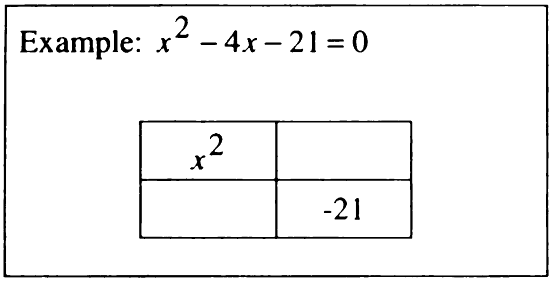


Figure 34. Megan's Boxing Example in Lesson 2.3

Megan next tells the students to fill in the two x's on the outside of the box because they should know what those have to be (Figure 35).

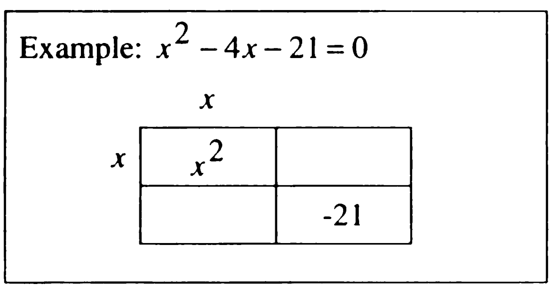


Figure 35. Megan's Boxing Example in Lesson 2.3

After students copy this into their notes Megan directs them to write out all of the factors of 21. As students do this Megan also writes out the numbers 1, 3, 7, 21 on the overhead. She suggests to the students that they try using -3 and 7 as factors of -21 because they know that one of the factors will have to be negative and she proceeds to write these on the outside of the box (Figure 36).

Example: $x^2 - 4x - 21 = 0$

	x	-3
x	x^2	
7		-21

Figure 36. Megan's Boxing Example in Lesson 2.3

She then proceeds to do the rest of the required work to fill in the box (Figure 37).

Example: $x^2 - 4x - 21 = 0$

	x	-3
x	x^2	$-3x$
7	$7x$	-21

Figure 37. Megan's Boxing Example in Lesson 2.3

To check their work Megan tells the students that they need to add the two x terms to be sure they sum to -4 as desired (Figure 38).

Example: $x^2 - 4x - 21 = 0$

	x	-3
x	x^2	+ $-3x$
7	$7x$	-21

Figure 38. Megan's Boxing Example in Lesson 2.3

Megan tells the students, and many appear to notice for themselves, that the sum of -3x and 7x is not -4x as desired. She then asks the students "what should we do?" As the students chatted about what to do one student in the class quietly answered that they could try to switch the negative sign. Many of the students in the class did not quiet down to hear this idea. Upon hearing the students suggestion but without repeating the idea or asking the student to say it loud enough for everyone to hear, Megan applied the idea on the overhead notes by switching the signs and she then moved on to the next problem.

Although Megan did not specifically reference her own selection of these particular factors in her lesson plan or any of her interviews, other evidence indicates it may have been purposeful. First, Megan flagged the fact that her mentor teacher shared with her that students have difficulty choosing factors and in particular knowing what to do when one negative factor is needed. Second, Megan used these factors in presenting the example both in her Focus Class and in another class earlier in the day which could indicate that she was planning this intervention to address the anticipated student difficulty that Mrs. Starns told her about.

Clearly this mini-case differs from the previous one in that Megan both anticipated a student difficulty and found a way to address it during her lesson. Although her attempt was commendable, the execution during the Focus Class may not have produced the desired effect of addressing the difficulty for all students because not everyone heard it and the idea itself did not appear to be made public, only the result. Because the student suggestion to change the sign was done so quietly and executed by Megan so quickly the other students may not have had time to really consider or understand this idea. Also, because Megan did not call more attention to the idea and the outcome of switching the negative signs some students may have missed the method all together. This was evidenced to a certain extent the next day when students struggled with "playing" with the factors until they could find the ones that worked. Despite all of this, this case does represent an example of a preservice teacher drawing on another teacher as a resource, namely her mentor teacher, Mrs. Starns, to anticipate students' difficulties and devising a strategy to address the potential difficulty during her lesson. Now that the nature of Megan's anticipating over the first semester of her internship has been described, the next section of this chapter addresses the influence of the contextual factors on her practices of anticipating SMRs.

5.2 The Factors of the Context

Research Question 2. What factors within the contexts of a teaching internship (a field experience and accompanying university course) promote or do not promote the practices of one preservice teacher anticipating students' mathematical responses during lesson planning?

The second research question addressed in this study focuses on the interactional aspect of the case. Greeno (1998) describes this aspect as examining the "interactive systems of activity in which individuals participate, usually to achieve objectives that are meaningful to their more general identities and memberships in communities of practice" (p. 6). While the first part of this chapter focused on Megan as an individual and her lesson planning practices, this part assumes a broader lens to explore the factors present in the systems, or contexts, in which she participated.

In order to investigate these contexts and their potential effect on Megan's practices a sociocultural framework was used which had previously been employed by Goos (2005b) to examine the contextual factors that influenced one beginning teacher's use of technology in his teaching. This framework was well suited to the investigation of the second research question because it also seeks to explore the effect of different contexts. Goos' (2005b) framework includes three zones of interest: (1) the Zone of Proximal Development, (2) the Zone of Free Movement, and (3) the Zone of Promoted Action[16]. Together, the descriptions of these three zones in this case study provide a detailed portrait of the ways in which the two contexts, along with Megan's own skills and desires for her teaching, interacted to shape her participation in this practice of anticipating students' mathematical responses (SMRs) in her lesson planning.

As described in section 2.3, the Zone of Free Movement (ZFM) and the Zone of Promoted Action (ZPA) will be further subdivided by the four principles identified by Engle and Conant (2002) as promoting productive disciplinary engagement. The presence or absence of these principles in the ZFM and ZPA will illustrate the influence of each context on Megan's practice of anticipating SMRs. These elements of the contexts, including Megan's own choices, influenced her actions as traced by the anticipation maps in the first part of this chapter. The second part of this chapter is organized using Goos' (2005) three zones and concludes with a summary of the findings in the first part of the chapter as they relate to all of the zones.

5.2.1 Zone of Proximal Development

The Zone of Proximal Development (ZPD) is a construct of learning originally defined by Vygotsky as "the distance between a child's independent problem solving capability and the higher level of performance that can be achieved under adult guidance or in collaboration with more advanced peers" (Goos, 2005b, p. 37). Since the original development of the idea, the ZPD has been applied to the teacher education context to

[16] Each of these zones as characterized by Goos (2005) are described in detail in Chapter 2.

examine the learning of preservice teachers. In this context the ZPD is described as "a symbolic space where the novice teacher's emerging skills are developing under the guidance of more experienced people" (Goos, 2005b, p. 37).

Goos (2005b) further articulated ZPD for her study in a teacher education setting which examined the use of technology, as the preservice teacher's: "(1) skill/experience in working with technology, (2) pedagogical knowledge (technology integration), and (3) general pedagogical beliefs" (p. 40). It can be assumed that the role of the more advanced peers, or teacher educators and mentor teachers in this case, falls under the other two zones and for that reason is not included in this characterization of ZPD. Thus, the ZPD in this study is focused solely on Megan and her skills, experiences, knowledge, and beliefs as they relate to anticipating SMRs and mathematics teaching in general.

The next sections describe Megan's ZPD using three parallel elements of ZPD for anticipating SMRs: (1) skills and experiences anticipating SMRs, (2) pedagogical knowledge for anticipating SMRs, and (3) general pedagogical beliefs.

5.2.1.1 Skills and Experiences Anticipating SMRs

Megan's skills and experiences anticipating SMRs were developed in her senior year methods course. During this time Megan was introduced to the practice of anticipating SMRs as part of the Stein et al. (2008) model for orchestrating productive mathematical discussions. Megan participated in this practice as part of creating seven separate lessons in which she made use of the common lesson planning format used in the secondary methods courses (Appendix B). Early in her internship year Megan reflected on her experiences anticipating SMRs using the lesson planning format the previous year:

> I would go through and do all of the stuff [in the format], like the standards and the goals... Then I would go and do the [launch, explore, and summarize] ... And the big thing with [the format], that I really liked, was that it got you to think what the students were thinking and then the questions you would want to ask them and how you'd want to answer them. I feel like I don't get that as much with doing the lecture style things. [In-Depth Interview 1, September, 2008]

This quotation from Megan is evidence that she had experiences anticipating SMRs prior to her internship year, and further that she identified anticipating SMRs as a central practice of the lesson planning format and one that she enjoyed. This quotation also illuminates the fact that Megan enjoyed using the lesson plan framework to create all of her lessons during her senior year.

In addition to using the format provided by instructors in her senior year methods course, Megan twice completed an assignment in which she used teaching journals to research common student naïve conceptions. Megan's responses to the Lesson Planning Survey (LPS) indicated that during her senior year she also participated in other practices of anticipating. In the survey she responded that she always consulted the curriculum's teacher guide, talked with a methods instructor about her lesson ideas, and completed the task herself when planning lessons. She also responded that for lesson planning purposes she almost always read articles about the content she was teaching and sometimes consulted her senior-year mentor teacher and considered the needs of particular students. In a later interview Megan clarified her response about sometimes consulting her mentor teacher by stating that "he would sometimes give me suggestions but he didn't do it all of the time" [In-Depth Interview 1, September, 2008]. This quotation indicates that it is likely her interactions with her mentor teacher did not often include the sharing of SMRs, but instead the giving of suggestions. She also noted in this interview that during her senior year she participated in interactions with the other preservice teachers in her methods course around their lesson plans. This occurred through informal discussions; "discussing what issues you're having with lesson planning or ideas and to brainstorm with them. I think brainstorming was a big thing, [just going] through ideas" [In-Depth Interview 1, September, 2008].

Megan's experiences in her senior year methods course exposed her to all of the individual practices of active/purposeful anticipation. Her own responses indicate that as part of that course she made use of curriculum materials and consulted other teachers in order to anticipate SMRs, and sometimes took the position of students, when planning lessons. In addition, assignments in the methods course required her to seek out and make use of literature on students' possible naïve conceptions and to complete mathematical tasks in multiple ways. One of Megan's responses on the LPS indicated that she had linked at least some of these activities to the practice of anticipating. She responded with the following when asked if she thought anticipating SMRs was important and how she accomplished in her past lesson planning:

> Yes, because in a student centered class a teacher needs to be prepared for various issues and how to provide a solution. In addition, it helps the teacher guide conversation for student learning. I try to do this by looking up articles on misconceptions, talking to my mentor teacher, and thinking of misconceptions on my own. [Lesson Planning Survey response]

The quotation indicates both that Megan sees anticipating as an important practice and implies that she intends to continue to make use of this practice. Megan's response also highlights a final important aspect of her skills and experiences anticipating SMRs during her senior year methods course. All of the lessons the preservice teachers taught in the senior year methods course were required to be designed around open-ended tasks. Using this type of task along with orchestrating student discussion based on the mathematics of the task was part of what was referred to in that class as student centered. Thus, all of Megan's skills and experiences anticipating SMRs during that time developed and occurred around her understanding of student centered teaching practices. Megan's own responses provide evidence that she connected the practice of anticipating to using the lesson plan format and student centered teaching. These connections appear to be a key factor in her practices of anticipating SMRs during her internship year. The next section describes Megan's knowledge for anticipating SMRs.

5.2.1.2 Pedagogical Knowledge for Anticipating SMRs

As described in Chapter 2, knowledge of content and students, whether based on distributed or experiential knowledge, plays a role in what SMRs a teacher anticipates. Megan's responses on the LPS indicated that she had knowledge of content and students for anticipating in a particular content area. One portion of the LPS asked the interns to anticipate SMRs in the context of teaching students about angles and using a protractor. Megan indicated in her survey responses that this was content she had discussed during her senior year methods course and also content that she had taught during that time. When asked to list all of the possible SMRs for learning about angles and measuring angles with a protractor Megan produced the following list in her survey:

- Students may confuse acute and obtuse angles.
- Students may have difficulty knowing how to use the protractor.
- Students may not know to extend the lines of an angle in order to use the protractor.
- Supplementary angles and complementary angles may get confused.
- The protractor has two sets of numbers on them. The students might use the wrong angle measurements.
- Students may get confused with radians and degrees.

This response exemplifies a portion of the results discussed in the first part of this chapter, which indicated that Megan's knowledge for anticipating was often based on her own teaching or learning experiences and that what she anticipated often dealt with mathematical procedures. These anticipated SMRs focused on knowing how to make use of the protractor and distinguishing between two terms (i.e. acute and obtuse) that they likely had learned already. These SMRs that Megan anticipated early in her internship experience display similar features of the majority of those she anticipated throughout the semester.

Although Megan responded in the LPS, and at other times, that she was aware of other methods for drawing on knowledge for anticipating SMRs, she rarely chose to make use of them in her internship year teaching. In fact when specifically asked during a final interview in December, after she had been in the internship experience three and a half months, if she had considered any misconceptions that might arise she stated: "It's very interesting the different misconceptions that you stumble upon as you teach the stuff. So even though you could research stuff, I learn a lot just from the kids [Lesson 3.3 Pre-Interview, December, 2008]. The next section describes Megan's general pedagogical beliefs.

5.2.1.3 General Pedagogical Beliefs

Megan's general pedagogical beliefs were based on a commitment to student centered practices. Megan defined student centered as:

> The students are conversing among one another to get to the answers. And this allows students to work with each other and stumble upon answers, that's what I mean by student centered. They're discovering the math on their own, well on their own but I am also helping or mediating. [This makes] more meaningful learning. [Cool Stuff 1 Pre- Interview, October, 2008]

Megan again connected using the lesson plan format to teaching in a more student centered way in an informal conversation with her field instructor.

> So to me student centered learning is doing our whole lesson plan [format]. So you would do a launch and explore where the kids are doing everything. And then you do the summary. You know, ALL that. And I want the kids to be discovering things on their own. [Informal Conversation with Field Instructor, November, 2008]

Many of Megan's comments about the teaching she was doing in her internship class were contrasted with her desire to do student centered teaching.

> I would like to see things go from me [lecturing] into more open-ended, group centered, student centered type things. And that's where I want to develop over the year because right now its very lecture based, teacher asking students

questions, and I want more students asking students questions or more of that kind of thing. [Lesson 1.5 Post-Interview, October, 2008]

> Right now its very much example based, very concrete, setting things out, writing definitions, writing concept type things. Very concrete. And I'd like to see it eventually transition into more student centered open tasks... And more of me being a facilitator instead of the lecturer. [Lesson 1.5 Post-Interview, October, 2008]

> Hopefully I'll be able to have some opportunities to do some more student centered things again. [Lesson 2.3 Post-Interview, November, 2008]

Megan's comments indicate that for most of the semester she was teaching in ways that were counter to her beliefs about how mathematics should be taught and learned.

Overall, Megan's ZPD was comprised of all of the discrete skills needed for anticipating SMRs as well as the desire to implement student centered pedagogies, which in her own words included anticipating SMRs. In this way, Megan was poised for further guidance in the direction of these practices. However, in her past practices of merely getting suggestions from a mentor teacher and brainstorming teaching ideas with other, inexperienced, preservice teachers, she did not appear to have had experience in using other teachers as resources for anticipating. Based on this lack of experience in using other teachers in this way, the position of the two contexts with respect to making use of other teachers would become a critical feature that both supported and constrained Megan's anticipation of SMRs. The next section describes the Zone of Free Movement in which Megan worked at both Logan High School and the university.

5.2.2 Zone of Free Movement

The Zone of Free Movement describes that which is possible for the intern (Goos, 2005b). In this way, this zone represents the features of the contexts that enabled or constrained Megan's practices of anticipating SMRs. In Goos' (2005b) study of a preservice teacher attempting to use technology in his teaching, the ZFM was comprised of several key elements:

- access to hardware, software, and laboratories;
- access to teaching materials;
- support from colleagues (including technical support);
- curriculum and assessment requirements; and
- students (perceived abilities and behavior) (p. 40).

As described in Chapter 2, these elements resonate with one of the principles that Engle and Conant (2002) describe as fostering productive disciplinary engagement for students, namely providing students with relevant resources. In addition to this, another element of Engle and Conant's principles also relates to what is possible for the intern and that is giving interns authority to address problems. As previously explained, this study applies Engle and Conant's principles to intern teachers. These two principles are relevant to this study because they characterize constraints and affordances relevant to Megan's practices in these settings and they are represented by the resources Megan had access to in each of the settings and the authority she was given. They will be referred to simply as resources and authority and will frame the discussion in each of the two following sections.

5.2.2.1 The University

The university setting provided Megan with both resources and authority that contributed to her ZFM while at the university. Megan's resources while at the university included her instructors, the other interns, as well as a variety of curriculum materials.

Both the methods instructor and the field instructor had experience teaching middle and high school mathematics. Their teaching experience as well as their other experiences in the mathematics education community made them knowledgeable of both SMRs from their own experiences and resources for findings tasks and information on SMR, which was often shared with the interns[17]. Dr. Rundell noted that he shared his knowledge of SMRs when providing feedback to the Cool Stuff lessons. "I actually provided all of the feedback on the lesson plans myself. So they got, to some extent, some expert opinion on how students might think about the task" [Methods Instructor Interview, October, 2008]. Megan also stated that she received some insight into SMRs from her field instructor Emily, but that this usually came after her teaching. Although Megan was required to send her lesson plan to Emily in advance of the observation, there is no evidence that she asked Emily for help in anticipating SMRs for any of the lessons.

The interns themselves were often put in the position of serving as resources to one another in the methods course through sharing their experiences and providing each other feedback. Although this was built into the course in various ways (e.g. case stories, Fireside chats, blog, and numerous class discussions), Megan rarely made use of the other interns in this way. "I've known the people who are teaching quadratics and I've known the people are teaching other things but I've never actually discussed it with them" [In-Depth Interview 2, December, 2008].

The curriculum resources that Megan had access to at the university included several sets of materials with open-ended student centered tasks and were available in the methods course classroom as well as the university library. In addition, some of these

[17] The practice of sharing resources was a prevalent part of the course culture and is further discussed in Chapter 4.

materials also contained SMRs in their teacher resource materials. On the first day of the methods course Dr. Rundell reminded the interns that these materials were available to them in the methods classroom. He again highlighted their availability during the third class when the interns were brainstorming lesson ideas for their Cool Stuff 1 lessons. Beyond the resources available to the interns in their university classroom, the required text for the course was the National Councils of Teachers of Mathematics (NCTM) Research Companion to Principles and Standards for School Mathematics (Kilpatrick, Martin, & Schifter, 2003). This compilation of research findings provides a wealth of information on student learning in a variety of areas, including algebra which was the mathematical domain of Megan's Focus Class. Another resource that was provided to the interns at the university was access to a variety of websites that were posted on the class wiki for finding tasks and looking up research on the internet. When asked specifically about the resources that the interns had access to in order to lesson plan and anticipate SMRs Dr. Rundell mentioned all of those previously described and added the mentor teachers to the list.

> And they have access to their mentor teachers, they have access to whatever materials they have in their mentors teachers classroom to draw off of and certainly their mentor teachers expertise, since most of them have taught the courses that the interns are teaching in the past, are quite valuable for getting insights into how students into anticipating how students might make sense of a particular mathematics idea or mathematics task. [Methods Instructor Interview, October, 2008]

Although this was a resource of the school and not the university, it is important to note that Dr. Rundell included it as an available resource for lesson planning and anticipating SMRs.

As a student in the methods course Megan was also required to be a member of the National Council of Teachers of Mathematics (NCTM). This membership allowed her access to the *Mathematics Teacher*, a high school teaching journal published by NCTM. This journal, as well as the middle school teaching journal, *Mathematics Teaching in the Middle School*, that was available at the university library, contained both student centered tasks and SMRs in its pages.

The second element of the ZFM that promotes productive disciplinary engagement is giving interns authority to address problems. In this context it means that the interns had the authority to determine the direction of the class discussions based on their own experiences in their field placements and to negotiate their assignments and due dates. While in the university setting Megan had all of the authority afforded a beginning professional in a collaborative community. Like all of the other interns she had the authority to question ideas and norms during class discussions and even to change the due dates of her assignments when necessary. Also, Dr. Rundell, the instructor of the methods course, rarely dispensed knowledge to the interns. He instead allowed them to discuss their problems and come to consensus on their own when appropriate. In many ways his teaching strategies mirrored those of Magdalene Lampert, considered by many to be an expert mathematics teacher, as described by Leinhardt and Steele (2005). Though Leinhardt and Steele describe Lampert's role in facilitating mathematical discussions of grade five students, Dr. Rundell's actions in the facilitating the discussion of the interns shared many of the important features.

> We see a teacher who facilitated dialogue around a predetermined set of connected topics, selectively allowing for asides that assisted in developing conceptual material and occasionally engaging in more bounded explanations about a particular subskill. Lampert is seen standing to the side of the dialogue;

> she neither led the class through a presentation of material and guided questioning, nor did she simply pose a problem and step out of the way, allowing for unbounded exploration that somehow results in students bumping into the mathematics. She succeeded in standing to the side by creating dialogues that fulfilled the conditions of an instructional explanation using the exchange of ideas in ways that chart a sensible, coherent, and complete path through the mathematics. She stepped into the mathematical community in part as a member of it and in part as the creator and director of it. (Leinhardt & Steele, 2005, p. 133)

In much the same way, Dr. Rundell was both a member of the community and its director. In this enacting this role the interns in the class were also invited in as members of the community, and thus were afforded the authority of a beginning teaching professional.

Megan's authority in the university setting had very little to do with her actual authority in the school setting. The only time that Megan's authority from the university impacted Megan's authority in the school was during the Cool Stuff assignments. On these two occasions the authority of the university allowed her make changes to fulfill her university assignments that she would not normally have been able to make.

Overall, the university ZFM afforded Megan the use of a variety of resources as well as a great deal of professional freedom. Despite the resources available in the form of curriculum materials and other teachers (including interns, her field instructor, and the methods course instructor), Megan made limited use of them in her lesson planning. When these resources were directly provided to her, either through case story interactions or in the form of instructor feedback on lessons she turned in, she made use of them. But, she did not on her own seek out any of these resources in order to help her anticipate SMRs. The next section describes Megan's ZFM, comprised of the resources available to her and the authority given her, at Logan High School.

5.2.2.2 The School

The ZFM of the school context afforded and constrained Megan's abilities to anticipate SMRs in different ways than the university setting. Megan had access to a different set of resources in the school setting that included the class curriculum materials, her mentor teacher and her mentor teacher's notes from previous years, and the larger mathematics teacher community at the school.

The first of the resources that Megan had access to at the school was the class curriculum materials, which included the student and teacher texts as well as the publishers set of accompanying worksheets. The textbook supplied very few SMRs and presented the materials via examples, definitions, and theorems along with numerous practice problems. Even those SMRs that were supplied in the textbook were not used by Megan.

> I usually don't read the book...We get our homework from the book and use problems from it for the quizzes. So even though we say we write it ourselves, that's where we're pulling things from. And everything else, like our vocab quizzes are based on the book, our tests are based on the book because we go by the chapter objectives and pull problems for that. [In-Depth Interview 2, December, 2008]

Megan noted on several occasions that she felt constrained by the lack of availability of resources to choose tasks from at the school to support her in enacting more student centered instruction.

> If I had the right materials, then it will be easier to do more often. [Cool Stuff 1 Post-Interview, October, 2008]

> It's hard because my mentor does not already have those tasks available for me to use. So like I would have to go out and find my own. [Lesson 3.3 Post-Interview, December, 2008]

In both of these instances Megan is contrasting her experience with her perception that other interns were in settings that did provide such resources, either through curriculum materials or mentor teachers' personal libraries of outside resources. She did not seem to view the university resources as being provided for her use in the same way. Given that Megan appeared to connect the use of student centered tasks to the lesson plan format and the lesson plan format to the practice of anticipating SMRs, the lack of student centered tasks may have been a factor that contributed to her lack of actively/purposefully anticipating SMRs in the field experience.

The second resource available to Megan at the school was her mentor teacher Mrs. Starns. Throughout the semester Megan made use of Mrs. Starns' class notes from previous years.

> She has a lot of stuff already done. So she has the notes all ready in a binder for each class... So for now, just for this first little bit, I'm going to use hers... just to see where she gets her things from gives me an idea of stuff, so that's nice for right now. [In-Depth Interview 1, September, 2008]

Megan pointed out that Mrs. Starns' notes only included the notes and examples she was going to use. She had not worked out the examples or included any thoughts about anticipated SMRs. Used in this way Mrs. Starns' notes were not a resource that helped Megan anticipate.

Mrs. Starns also served as a resource for Megan through their verbal interactions. Despite their almost daily communications, the findings presented earlier in this chapter evidenced the fact that Mrs. Starns was not often a resource for anticipating. The interactions between Megan and Mrs. Starns often focused on what to teach, that is which section to do next, as opposed to sharing past experiences with students and content:

> [We focus more on] the schedule, like 'what do we need to do' and 'what sections are we going over,' and 'should we do the reading packet or not'. So I don't sit down and plan these with her because I think she thinks that the math shouldn't be an issue any more. I mean if it is we'll go over it, but the organizational [part], she feels that's how she can help the best right now. [In-Depth Interview 1, September, 2008]

> So when I was just doing the regular lesson plans with my mentor we would just basically plan out the week and say what we're going to do each day and then I would take her notes and the book and do things on my own. [In-Depth Interview 2, December, 2008]

The fact that Mrs. Starns did not often share her teaching experiences in order to help Megan anticipate SMRs could be attributed to her objectives for Megan during the first semester. Mrs. Starns stated early in the semester that her goal for Megan was that she would speak clearly and present herself as a strong person and female in front of the class. Given this, Mrs. Starns might have viewed their interactions as adequate to helping Megan progress in this area. It is important to note that Megan rarely sought out Mrs. Starns as a resource for anticipating.

Available time to discuss lesson plans was another limitation in making use of Mrs. Starns as a resource. By the final week of observations there was very little conversation between Megan and Mrs. Starns about the lesson plans at all. Megan noted before teaching one of the lessons that week, "actually, my mentor and I didn't have time to discuss this from yesterday and so I just recorded her notes that she did during first hour" [Lesson 3.2 Pre-Interview, December, 2008]. That same week Megan's field instructor, Emily, observed her teaching and asked her afterwards in the debrief a question about a choice she made during her teaching.

> Emily: What made you decide not to read the ant problem before they did it? What was the ant problem even?

Megan: Well, what happened was that Mrs. Starns does the reading packet [in first hour] and so I wanted to do just what she did. That's how she presented it, so I did it like she did.

Emily: Okay. Are the students expected to have read it before?

Megan: No... The actual question is: Would this ant have a surface area large enough to meet its oxygen need? If you read it you can actually answer that question.

Emily: Okay. So you only need to do the first [part of the question] because tomorrow you're going to answer the oxygen [part of the question]?

Megan: Nope, that's it...I don't know if she did it for time's sake that she only did surface area and volume because then you're still working with the roots and different things, you're still doing those relations. But I think that she just decided not to do that question because of time and cause it might confuse them more, that might be why. We didn't have time to chat. We don't chat about these that much ahead of time. [Field Instructor Lesson Debrief 2, November, 2008]

When asked specifically about times when she and her mentor teacher discussed possible SMRs Megan stated that this did not happen often and offered lack of time as the explanation. "I think sometimes it's just the flow of the day and it gets busy and we know what we have to get done so we don't really spend a lot of time [talking about that]" [In-Depth Interview 2, December, 2008]. The reality of this situation is a stark contrast to Dr. Rundell's vision, which he often shared with the interns, of the mentor teacher serving as a resource.

Finally, the larger community of mathematics teachers at Logan High School was a possible resource for Megan in anticipating. However, because the interactions between Megan, Mrs. Starns, and the two other members community were limited to monthly professional development meetings and occasional conversations in the lunch room, Megan may not have seen a ready opportunity to get feedback from the other two mathematics teachers on how students might react to her lessons. In addition, the conversations between teachers in the lunch room and the hall were often social in nature or related to student discipline issues. It seemed to be that it was not the norm in the school to take part in conversations about teaching with other teachers.

Although not necessarily a resource provided by the school, time commitments imposed by the school constrained Megan's ability to think very much about lesson planning and therefore to anticipate SMRs. At the beginning of the year Mrs. Starns and Megan decided that Megan would grade all of the papers for Algebra 2 and most of Math Analysis, a total of four classes. This choice was counter to the intent of the program that expected Megan to gradually take responsibility for the teaching of more classes over the year but still allow time for the interns to co-plan with their mentor teachers and time for reflection. Megan found it difficult to prepare lesson plans with all of the extra grading she was doing for Mrs. Starns along with what she needed to do for her university courses. When asked early in the semester why she was not making use of outside resources such as teaching journals to plan lessons, she stated that even though she wanted to use them she simply did not have the time.

> Yes, I would love to [use] them. By the time I come home at night I have a pile of papers to grade. And that's new to me so I have to get used to that. And want to get ahead on lesson plans so I have those to do and then if I have anything for the next day and then I have my homework for my teacher education classes. So by the time all that's done I have to have some time for myself, maybe a just little bit. Getting articles just isn't on the top right now. [In-Depth Interview 1, September, 2008]

Although the grading situation was corrected in the middle of the semester when Dr. Rundell intervened, Megan perceived the excessive grading as a major hindrance to her lesson planning. When asked what impacted her lesson planning over the semester she stated: "I think the amount of grading that I had this semester really influenced my planning because I didn't have as much time to plan, and that was probably three fourths of the semester" [In-Depth Interview 2, December, 2008].

The second element of the ZFM to be discussed is Megan's authority in this context. In this case authority refers to Megan's ability to make decisions about what was going to happen in the classes she was teaching. Evidence indicated that Megan's authority in the school setting was minimal. First, Megan did not have the authority to change her mentor teachers' weekly schedule in any substantive way when she was teaching. During the two or three days of the week when there was some flexibility Megan was only given 20 minutes, the allotted lecture time, in the class to try her own ideas.

> She has given me as much freedom as I want to do what ever during that lecture time. She still wants to have the structure and the routine, but during that chunk of time I can do what ever I want. [Field Instructor Lesson Debrief 1, October, 2008]

Megan found during the semester that this amount of time was not sufficient to try all of the student centered activities and ideas that she wanted to.

> I have these ideas of what I want to do. I want to have more student centered learning, I want to have more cooperative stuff. But then once I try do it like with Spiderman [and his] parabolas [I run out of time]...but [because of the] vocabulary quiz and other things you have to do, which are good things, you run out of time... We don't have the leniency of doing something where you can take the whole hour and do what ever you want. [Lesson 2.5 Post-Interview, November, 2008]

Megan found this to be true in teaching her Cool Stuff 2 lesson when she asked Mrs. Starns if it would be okay if she continued the lesson into the following day. Although Mrs. Starns had allowed her to deviate from the schedule to teach the lesson, she would not allow the lesson to continue into the next day because of the scheduled binder check and Game of Life. This instance occurred even though Megan was in her second lead teaching period and was supposed to be making all of the instructional decisions for her classes at that time.

Megan also lacked the authority to make decisions about her teaching outside of the schedule structure. During her two lead teaching periods when Megan was supposed to be fully responsible for the teaching of her classes, Mrs. Starns would interrupt her during class and change a due date Megan had just assigned or provide a different explanation to the students without explaining why an alternate was needed. On one occasion Mrs. Starns made a change to the plan for the day without consulting Megan.

> I had something else prepared… But she decided, I don't know if she was talking to a kid, but they decided they would have the odds due and then they would have the evens due the next day. I probably would have just rather had them do the odds and just go over like one or two problems to start them and get them through the graphing part and they could solve the rest or something like that. [Field Instructor Lesson Debrief 1, October, 2008]

Megan accepted her lack of authority in her lesson planning and yielded to her mentor teacher's wishes. This was reflected in Megan's response to a question asking how her lesson planning had changed over the course of the semester,

> This is sort of complicated. I think that my literal lesson planning has changed in that now it's just a lesson plan lecture style lesson. I think that has changed because of my mentor and I think that it has changed because of what she wants for the class. However, my desires for my lesson plans, for [what I want them to be] has not changed" [In-Depth Interview 2, December, 2008]

A possible reason for Megan being reluctant to try to assert more authority in the classroom came up in an informal conversation she was having with Emily after the methods course one day. Megan and Emily were brainstorming possible changes that Megan might try to make to Mrs. Starns' schedule in the second semester when she was to take more control of her classes. Megan noted that Mrs. Starns "has reasons for why she does things and she will shoot them at you" [Informal Conversation with Field Instructor, November, 2008].

Overall, the two contexts varied drastically in the resources and authority they provided. Within the school context Megan's authority and access to resources was limited by lack of time, Mrs. Starns' strict schedule, and the lack of another teacher with a similar vision of teaching to share activities and experiences. Given the connection Megan made between student-centered activities, the lesson planning template, and anticipating SMRs, the lack of student-centered tasks in the school may have been a major factor that kept her from anticipating SMRs. However, there were student-centered tasks available at the university or possibly in her own textbook or by asking other interns, the university methods instructor, or field instructor that Megan rarely made use of. Additionally, although the methods course instructor gave her some feedback in the area of anticipating SMRs, Mrs. Starns did not volunteer this kind of information and Megan did not seek it out. Megan was not making use of any resources or authority unless they were provided to her by someone else. In this way, the lack of resources and authority at the school could be viewed as a failure on Megan's part to seek out the resources she needed and assert her own beliefs to teach in the way that she wanted, a way that she connected with anticipating SMRs. The next section describes the Zone of Promoted Action in each of the settings.

5.2.3 Zone of Promoted Action

The Zone of Promoted Action (ZPA) describes the particular teaching skills or approaches that are promoted by teacher educators, field instructors, and more experienced teachers (Goos, 2005b). In this case this zone is represented by the actions of anticipating, or those that relate to and support anticipating, that are promoted in the two contexts. Because they were such an integral part of the university context the other interns were also included in the group of those who could promote actions. In Goos' (2005b) study the ZPA was comprised of three key elements:

- preservice education,
- practicum/beginning teaching experience, and
- professional development (p. 40).

As with the ZFM, certain aspects of the ZPA resonate with two of the principles that Engle and Conant (2002) describe as fostering productive disciplinary engagement. They are problematizing subject matter and holding students accountable to others and to shared disciplinary norms. Applied to the interns, these represent problematizing mathematics and mathematics teaching and holding the interns accountable to other teachers and shared norms of mathematics and mathematics teaching. These two principles will be referred to as problematizing and accountability and will frame the discussion in each of the two following sections.

5.2.3.1 The University

Within the university context the ZPA comprised a vast array of ideas and practices. This section will begin with a description of how the subject matter was problematized in this setting followed by a discussion of how this context held Megan and the other interns accountable to each other, to their instructors, and to a certain set of disciplinary norms.

The university context provided experiences in which mathematics and mathematics teaching was problematized in almost every class and during many of the interactions that occurred outside of class. Mathematics itself was problematized through the semester-long focus on fractions and ratios. Dr. Rundell engaged the interns in tasks around these two mathematical ideas and allowed them the opportunity to challenge each other's ideas. In the second methods class of the semester Dr. Rundell posed the question, What is the difference between a fraction and a ratio? A relatively heated debate occurred among the interns that lasted throughout the semester. Further questions were posed: Are all fractions ratios? Are all ratios fractions? What is the difference between the two? Why is the difference important for proportional reasoning? The interns would occasionally turn to Dr. Rundell and ask for a definitive answer, which he would not provide[18]. In the last class of the semester the interns were still discussing the issue after having read the chapter on fractions and multiplicative reasoning in NCTM's Research Companion to Principles and Standards for School Mathematics (Thompson & Saldanha, 2003). Several of the interns were still passionately engaged in the debate and ended the semester intellectually frustrated with the questions. This type of interaction problematized one area of mathematics for the interns, which allowed them to consider it at a different level and from different perspectives, and provided a model for them to problematize mathematics for themselves and their students in the future.

The teaching of mathematics was also problematized in the university methods course. This occurred broadly through Dr. Rundell's dual focus in the class on what he referred to as issues of "Now and Forever." Dr. Rundell saw his role in addressing the

[18] This is also an example of Dr. Rundell promoting mathematical authority within the group of interns.

Now issues as "responding to their real time needs" [Methods Instructor Interview, October, 2008]. This view is in accordance with how Engle and Conant (2002) described problematizing subject matter. "The core idea behind problematizing content is that teachers should encourage students' questions, proposals, challenges, and other intellectual contributions, rather than expecting that they should simply assimilate facts, procedures, and other 'answers'" (p. 404). Dr. Rundell accomplished this by making individual intern concerns public to the other interns each week during *What's Happening in Mathematics* (WHIM) time. The individual teaching concerns became problems for the entire class to tackle. During these discussions Dr. Rundell would ask the intern to share their story and would sometimes ask other questions in the course of the discussion. For the most part, he stayed on the sidelines of these discussions and did not offer "correct answers," but on occasion did share relevant stories of his own teaching.

Mathematics teaching was further problematized in the university methods course through planned class experiences. One example came from a case Dr. Rundell presented in which a mathematics teacher was teaching content in a new way than she had in the past. The case detailed the decisions that she made while teaching and included her own questions to herself about what she needed to do next. Dr. Rundell asked the interns to identify the teacher moves that contributed to student learning in this case and to explain why. During these and other conversations around case studies, the interns had the opportunity view the complexity of mathematics teaching from a perspective other than their own. While these experiences were not initiated by interns or based on their experiences, they also represented ways of thinking about teaching that were potentially new to the interns and different than what they experienced in their own learning of mathematics or what they were seeing in their field experience classrooms. In this way these experiences problematized the teaching of mathematics for the interns through alternative vision of mathematics teaching.

Interactions in Fireside chats also problematized the teaching of mathematics. Dr. Rundell would ask questions and probe for more information from the interns. The series of questions below were asked by Dr. Rundell in the third weekly Fireside chat when one of the interns stated that his students had performed very poorly on a test he had given that day. They are representative of the way he problematized the teaching of mathematics.

> Why do you think students did badly?
> So let's think about your test a bit. What was the content?
> Okay. Tell me about the instruction that went before.
> So tell me, what did you think they knew coming into the test?
> What did they do well and what didn't they do well?
> Why was memorization tough for them? And what is the value in memorizing these things? Okay, so how is it important for living in society?
> But we all know it, right? When do WE use it?
> [Fireside Chat, September 17, 2008]

In this interaction Dr. Rundell pressed the intern to think further about his statements by questioning, probing, and challenging the intern to articulate more about the experience and his thinking about it past his initial reactions. Megan's field instructor, Emily, asked Megan similar questions during a debrief conversation with her after an observation.

> Do you think that's what all of the students were having problems with? I know you only worked with those two specifically.
> When working with those two...what was their misunderstanding?
> [Field Instructor Lesson Debrief 1, October, 2008]

Finally, mathematics teaching was problematized through the Researchable Question assignment. For this assignment the interns worked in groups to design a research project based on their students learning. They carried out their projects and presented their findings at a poster fair on the last day of the methods course. Dr. Rundell's explained how this assignment related to anticipating SMRs.

> I think the researchable question assignment is kind of a retrospective on anticipating in some way. So for that assignment they are asked to identify a question that they are interested in answering about mathematics and how their students are dealing with mathematics and most of the time it arises from something that's come up in their class. For example, 'my students are having tremendous difficulty with operations with negative numbers. I wonder why that is.'... It really feeds back into anticipating and all of it seems to arise from failures in anticipating. 'I was surprised that my students couldn't do X' and then that leads to the idea that I might want to use that as my researchable question. [Methods Instructor Interview, October, 2008]

In both the problematizing of mathematics and teaching mathematics, Dr. Rundell created a situation in which anticipating SMRs was a reasonable practice in which to engage for a teacher. Since both the discipline and the act of teaching are comprised of multiple interpretations and uncertainties, the act of anticipating during lesson planning becomes an important tool in helping teachers support their students learning in fruitful ways toward the desired goals. As Dr. Rundell described it,

> If they've thought about how a particular way of thinking [represents] a mathematical idea and what moves they're going to make in response to that... then there's less kind of a cognitive load right in the moment of teaching and that's going to help them be more flexible in the classroom. [Methods Instructor Interview, October, 2008]

The second element of the ZPA in this frame is accountability to other teachers and to the disciplinary norms of mathematics and mathematics teaching. The university context created an environment in which the interns were both accountable to their methods course and field instructors as well as the other interns in the class. The methods course instructor and her field instructor both reviewed Megan's lesson plans and the field instructor watched her teach. Through their feedback they held Megan accountable to the disciplinary norms established by the community. There was some evidence that Megan only felt accountable to her instructors in her lesson planning when writing lessons for class assignments. When asked what her methods instructor expected of her daily lesson plans she responded that "he just goes by what my field instructor expects of me so it would just be what my mentor wants" [In-Depth Interview 2, December, 2008].

Through Dr. Rundell's creation of a collaborative teaching community in the class the interns were also held accountable to one another. This accountability was illustrated in a case stories assignment in which interns shared their ideas for the Cool Stuff 1 lesson assignment with other interns in small groups. Megan's group was comprised of herself and two other interns. As Chuck, an intern, shared his lesson idea he first commented that for the first part "students can do it two ways" [Methods Course Observation 5, September, 2008] and then went on to describe what the two methods he foresaw were. Megan and the other intern, Cathleen, press Chuck to think about how he will grade the activity and what exactly he will look for in terms of evidence of student understanding. Next, Megan shared her idea for her lesson and Chuck suggested that she needed to do the task herself before deciding if it is appropriate for her students. Cathleen stated that she liked the activity but was concerned it was too open-ended for Megan's students since they were used to lecture and note taking. Finally the third intern, Cathleen, described her ideas and explained that she was planning on using a launch that she saw in the methods course the previous year. In her explanation of her lesson Cathleen exhibited the already established norm of considering SMRs in thinking about her lesson. She stated that "hopefully it will work the same as it did last year" [Methods Course Observation, October 1, 2008]. She went on to further describe how students might interpret the activity she was considering. As an example referring to how students might think about the slope of a line she said "they might say 'because it goes up faster' or..." [Methods Course Observation, October 1, 2008]. In this instance the interns were accountable to one another to provide helpful feedback on their lesson ideas in order to improve them and accountable to established norms of anticipating SMRs, which is discussed further in upcoming sections.

Part of holding the interns accountable in the university setting was holding them accountable to the disciplinary norms associated with teaching mathematics. The disciplinary norms of mathematics teaching in this setting reflected the particular view held within the university community. This view included the use of tasks of high cognitive demand that engaged all students in discussion around important mathematical topics. Dr. Rundell described a particular goal of the class relating to this view, "certainly, working on how to facilitate discussions and how to plan for facilitating a large scale student discussion is something that we're going to work on this year with respect to lesson planning" [Methods Instructor Interview, October, 2008].

As previously described, Dr. Rundell often asked the interns to engage with mathematical tasks and to solve them in multiple ways. Doing so promoted the norm that approaching mathematical tasks in multiple ways was fruitful and expected. In addition to doing mathematics in this way, the interns were expected to take multiple solutions into account in their lesson planning. In explaining his expectations for the Cool Stuff 1 and 2 assignments, Dr. Rundell stated, "I'm looking for... complete student solutions to the task, a variety of representations, a variety of strategies, the ideas related to student thinking are clear, and it includes both correct and incorrect pathways to thinking about the task" [Methods Instructor Interview, October, 2008]. Megan mentioned this expectation when reflecting on her feedback from Dr. Rundell.

> When I did my Cool Stuff 1, he wanted me to really pay attention to student work and how that could impact my teaching and what to do and how to take all those materials and think about how the kids are thinking to help them. [In-Depth Interview 2, December, 2008]

Other practices of anticipating SMRs were also part of the norms of the university setting. Megan's field instructor, Emily, stated that her own expectations for Megan's lesson planning were that "ultimately the goal would be to predict the questions that the students are going to ask and the misunderstandings that they are going to have" [Field Instructor Interview, September, 2008]. Similarly, Dr. Rundell noted that in giving feedback on Cool Stuff lesson plans he also looked for anticipated student questions and thinking.

Dr. Rundell developed the norm of anticipating SMRs in lesson planning by building on the practices the interns participated in the previous year. "I went back to the five practices for orchestrating productive discussion of which anticipating is the first, and ... [said] 'if your lesson plan doesn't respond to these five things then there's something missing from it'" [Methods Instructor Interview, October, 2008]. He also reflected that in addition to assignments that called on the interns to anticipate SMRs, there was also a lot of tacit work that took place that supported the practice.

> It's not like we have a session on anticipating student thinking...There have been a couple of opportunities to make my own thinking and pedagogy visible in terms of how I think about orchestrating their learning experiences... I think seeing

> some of that in action where I've had opportunities to peel back the layers a little bit and show them 'hey this is how I prepare for this class' is really helpful in making it a little bit more real to them and helping them to understand that even though these practices are difficult to do, and anticipating student thinking in particular is really difficult to come out of your own head and start to think about, there is a pay off. [Methods Instructor Interview, October, 2008]

Dr. Rundell modeled this practice on several occasions during the methods course by presenting alternative solutions to a mathematical task after the interns had shared all of their solutions. His lesson plans were also held up as a model for the interns. In one class early in the semester in which Emily the field instructor had already discussed the detail of Dr. Rundell's own lesson plans for the methods course, one of the interns asked Dr. Rundell if he had thought of all of their wrong answers in his lesson plan. Dr. Rundell responded that his lesson plan conatined all of the incorrect answers he had seen in class.

Also part of the ZPA in the university context were the practices promoted within the intern community. Evidence from the Lesson Planning Survey (LPS) conducted at the beginning of the year indicated that many of the interns viewed anticipating SMRs as a disciplinary norm before beginning the internship year methods course. In the LPS the interns were asked about the activities they participated in to plan lessons in their senior year. Table 8 shows their responses.

Table 8. *Intern Participation in Specific Anticipation Activities*

	Always	Almost Always	Sometimes	Hardly Ever	Never
worked the mathematical task or solved the problem(s) I planned to give to students	8*	3	2	1	
consulted the teacher guide for possible areas where students might struggle or solution strategies they might come up with	3*	1	6	2	2
read articles about how students might engage with the content I was about to teach	0	2*	9	2	1
asked my mentor teacher about their experiences teaching the content	4	3	5*	2	0
thought about the learning needs of particular students in the class (i.e. Will this lesson make sense for Shannon in my 3rd period class?)	3	3	4*	4	0

Note. The asterisks indicate a response by Megan

Their responses indicate that many of them were participating in anticipating SMRs practices at least some of the time.

The LPS also asked the interns to consider why the practice of anticipating SMRs was promoted in their teacher education program. Most indicated that it was necessary to be prepared for teaching, which included: addressing misconceptions when they arise, making use of student solutions, and being ready to answer questions. Two of the interns approached the need for anticipating from another point of view. As opposed to thinking about how anticipating benefited them, they focused why they would anticipate in terms of what it would do for their students

> It puts us in the students' shoes. We have to think about what they are doing or thinking so we can catch that during our lesson. Without thinking about these things, we may miss important opportunities to discuss ideas and other solution strategies. [Lesson Planning Survey response]

> It is encouraged because if we don't think about how students process information then we might as well just have them read something previously written and learn from that. We need to think about what will confuse them so that we can clear mistakes up in creative ways without just correcting them but by helping them discover on their own. For example by leading them to confusion purposely in a sequence of problems where they eventually clear up their own questions and make conclusions. [Lesson Planning Survey response]

Overall, the responses to the LPS indicated that the interns were both familiar with the practice of anticipating SMRs and recognized its importance as they began their internship year teaching.

Findings indicate that the interns continued to view anticipating SMRs as a norm of mathematics teaching throughout the semester. They evidenced this in using each other as resources to anticipate by sharing their own experiences teaching content that others were teaching. In one discussion about the division of fraction one intern teaching in an eleventh grade class shared her past experiences with another intern about to teach fractions: "kids get so confused by fractions. They can do halves and fourths but once they get to thirds…," then referring specifically to adding fractions she tells the group "they add the top and the bottom" [Methods Course Observation, October 8, 2008].

This importance of this norm for the interns was also evident on one occasion when they attempted to elicit experiences from one another to help them anticipate SMRs when they taught content in the future. Regarding the outcomes of the Researchable

Question project, one intern asked "are we going to get to find out what they find cause I'm teaching that next semester?" [Methods Course Observation, October 22, 2008]. Another intern followed this question by asking "Are you trying to fill in the anticipation column in the lesson plan?" to which the first intern replied that she was. These interactions are evidence that not only did the interns view anticipating SMRs as a norm of lesson planning, but that they had begun to participate in active/purposeful anticipating by using each other as resources.

Overall, the university context attempted to provide experiences that would both problematize mathematics and mathematics teaching and hold the interns accountable to the instructors, each other, and disciplinary norms. The experiences are evidence that Megan had the opportunity to participate in these promoted practices in this setting. The next section describes the promoted practices that Megan engaged with in the school setting.

5.2.3.2 The School

Recall that the ZPA is comprised of the elements of problematizing mathematics and mathematics teaching and holding the intern accountable to other teachers and disciplinary norms. This section will begin with a description of how the subject matter was problematized in this setting followed by a discussion of how this context held Megan accountable to other teachers and to a particular set of disciplinary norms.

The school context appeared to make considerable effort not to problematize either mathematics or the teaching of mathematics for Megan. Mrs. Starns advice to Megan about teaching mathematics was often to "know your content." There was no evidence during observations or from interviews that Mrs. Starns and Megan had any discussion with each other about what it meant to know the content. In addition to not encouraging Megan to problematize the content for herself, Mrs. Starns did not encourage her to problematize the content for the students. She often advised Megan to be as simple and concise as possible in her presentation of facts and examples. One day before class Megan asked her about the kinds of questions she usually asked in order to engage students in helping her set up a problem during lecture. Mrs. Starns again told her to be concise and ask concise questions and stated "don't be too wordy with the Algebra 2ers; they don't like it" [Informal Conversation, Lesson 1.1 Observation].

The problematizing of teaching mathematics was also limited by Mrs. Starns. She created a weekly schedule for teaching that she used each year that included a test on every third Friday. Her lecture style of teaching that Megan adopted minimized unforeseen events in her classroom. Because Megan fully adopted her mentor teacher's approach during most of the first semester she also participated in other practices that minimized potential problems, such as unforeseen student questions. Megan noted this phenomenon in one of the interview. "Today I did a lot of talking and they didn't do any work together or any student centered things. So they didn't really have questions" [Lesson 2.3 Post-Interview, November, 2008]. In an earlier interview Megan was questioned about one of her stated misgivings that she did not have the opportunity to explore student thinking as much as she would like to. She explained, "I don't get to cause the students to think a different way or to scaffold them more in their thinking and guide their thinking. I think I'm more a dispenser" [In-Depth Interview 1, September, 2008]. Another method used by Mrs. Starns and adopted by Megan to minimize potential problems was to choose homework exercises to review in front of the class instead of asking the students which exercises they needed help with.

The problematizing of the teaching of mathematics was also limited in the school context by Megan's use of Mrs. Starns teaching notes from the previous year. Although there were some instances in which Megan would stray from her mentor teachers' notes and choose different examples for her own reasons, the availability of the resource meant that Megan was not compelled on a daily basis to make those pedagogical decisions herself. Mrs. Starns lack of problematizing is perhaps not a surprising finding. Problematizing is an inherently messy and difficult activity that only adds to the already complex nature of teaching. Perhaps for that reason Mrs. Starns saw any practice that problematized mathematics or her own teaching as something to avoid in her own teaching as well as something from which to shield Megan. This is suggested by her strict adherence to a weekly schedule and her insistence that Megan follow the same schedule. The result was that the lack of problematizing of either mathematics or mathematics teaching could have served as a negative catalyst for Megan to anticipate SMRs. If mathematics itself is straightforward and the teaching of mathematics is seen as the teacher clearly laying out what students are to learn without any input from them, then it would not be necessary to consider alternative student solutions, naïve conceptions, or student questions or difficulties because they would not occur.

Accountability to other teachers and to disciplinary norms is the second feature of ZPA. Within Logan High School, Megan was only held accountable to Mrs. Starns and her disciplinary norms because of the lack of an instructional community amongst the teachers at the school. As has already been established, Mrs. Starns disciplinary norms fell under the norms of a more teacher-centered, lecture-based stance on teaching mathematics. Thus some of her norms, which were also the norms she held Megan to while teaching at the school, reflected this stance. Several of Mrs. Starns disciplinary norms impacted Megan's opportunity to enact student-centered teaching practices, plan detailed lessons, and perhaps ultimately, to anticipate SMRs.

The first norm of Mrs. Starns' that influenced Megan's lesson planning and enactment was the previously discussed weekly schedule. When asked about Megan's daily schedule at the school Mrs. Starns replied that "she puts out the homework, she has the kids get it, we sometimes have bell work which is like a starter question and we'll go over the homework and she'll do her notes" [Mentor Teacher Interview, October, 2008]. Mrs. Starns was adamant that she thought following a daily and weekly schedule was very important and stated that when she was the math department chair for the district every teacher was on such a schedule and tested their students at the end of every three weeks, regardless of their position in the curriculum at the time. By holding Megan accountable to these daily and weekly norms, Mrs. Starns constrained Megan's opportunity to enact lessons in her own style that would potentially take more time than she was allotted.

The second set of norms established by Mrs. Starns dealt with grading papers and also influenced Megan's practice of lesson planning and anticipating SMRs in different ways. Mrs. Starns's gave primacy to the grading of papers each night, which limited the amount of time Megan had to plan lessons.

> She and I agreed that the homework was really important to get done, grade the night, the day they turn it in, so that they can receive it back the next day. Because we go over the homework the next day from that section from the previous day. So it was important that the kids got their homework back and got feedback right

> away. But the worksheets or the quizzes, we agreed that on Sunday nights is when we would have everything in, that would be fair. Just the homework was really important. [Mentor Teacher Interview, October, 2008]

Another aspect of the grading norms promoted by Mrs. Starns was that student papers were identified with their assigned numbers instead of names. Megan explained in an informal conversation one day that not having the students names on the top of the papers when she as grading them made it difficult for her to match the thinking she was seeing in the work to any particular student. When asked why Mrs. Starns used this method, Megan replied that she thought it was because it made entering grades into the computer easier. Finally, Mrs. Starns appeared to use grades to motivate students to participate. When Megan was getting ready to teach her Cool Stuff lessons, Mrs. Starns advised her to give students participation grades on their work in the class so that they would participate in the activity. These norms promoted a focus on grades that appeared to cause Megan to focus on grades rather than on planning for and trying to understand students thinking about mathematics.

Mrs. Starns also articulated specific norms for Megan's lesson planning. While there was no evidence that these norms prohibited Megan from anticipating SMRs, there was nothing built in to the structure of the plans that would promote the practice. Megan explained her mentor teacher's expectations for her lesson plans early in the semester.

> I don't do like the big elaborate lesson plan, but I do one of these for now cause this is what my teacher wants. So this is what the kids will do and this is what I will write on the board, it's pretty straight forward. And then this is what I have to do before class and this is what we're going to do during class and I'll go through that. And then I have stuff that I want to do during prep hour, after school, and at night. [In-Depth Interview 1, September, 2008]

Figure 39 is recreation of the lesson plan Megan described in the above quotation.

<u>Lesson Plan Week 1.4</u> Thursday, September 25, 2008 Focus Class: Algebra 2, Fourth Hour **<u>Student Schedule (to write on board)</u>** **<u>Algebra 2</u>** **Thursday: (Section 3.3)** Bell work Go over story problems Notes Textbook HW – Section 3.3: 21-48 left column, Story: 55, 56 **<u>My Schedule</u>** **<u>Before Class</u>** o Prep materials o Overheads for readings o Get out bell work on computer, turn on projector o Set out reading packet o Set out returned student work o Set out note cards o Set out Game of Life materials o Overhead, markers o Get note card box for notebook check **<u>Algebra 2</u>** **Thursday:** o Bell work section 3.2 o Getting started; 5-10 minutes ➢ Students have homework and reading packet to pick up ➢ Students get calculators ➢ Attendance o Announcements: ➢ Extra credit due Friday ➢ Notebook check tomorrow – will double count since we didn't do it last week ➢ Game of Life tomorrow	o Go over story problems 3.1: 57, 3.2: 53, 55 o Go over HW 3.2: 17 and 47 o Reading packet section 3.2 and 3.3 o Notes section 3.3; 10-30 minutes o Textbook HW – Section 3.3:21-48 left column, story 55, 56 **<u>Prep</u>** **Thursday:** o Attendance/Tardies/Discipline o Update Binder o Put homework on schoolnotes.com o Put make-up work in Absent Folder Bin o Print/create worksheets and answer keys o Get together quizzes for next week (1^{st} and 4^{th}) **<u>After School</u>** **Thursday:** o Update Binder o Write student schedule for Friday on board o Put notes/materials in Friday folder/book o Make Up Folder for important stuff o Lesson Plans for week 1.5 due **<u>Night</u>** **Thursday:** o Grade worksheets if not done o Final prep for Monday, Tuesday lesson and prep for Wednesday, Thursday o Send skeleton to field instructor

Figure 39. Recreation of the Lesson Plan Format Required by Mrs. Starns and Used by Megan on a Daily Basis

Because there is no attention given to students or mathematics content anywhere in the lesson plan format expected by Mrs. Starns, it can be inferred that she did not promote anticipating SMRs as part of the written lesson plan. Megan additionally completed the examples on her own in the notes template used by Mrs. Starns and given to students (Figure 40).

CHAPTER 3 SECTION 3

~~WHAT WE ARE LEARNING:~~ WHAT?

Graphing and solving systems of Linear Inequalities

~~WHY WE ARE LEARNING IT:~~ Inequalities = shading

→ $y = mx + b$ form!

~~FORMULAS:~~

Use calculator

SKILL EXAMPLES:

$\boxed{\text{Ex 1}}$ Graph system $x - 2y \leq 3$ ①

$y > 3x - 4$ ②

$y = mx + b$

① $x - 2y \leq 3$

$-x \quad\quad -x$ → Flip when mult or divide by negative

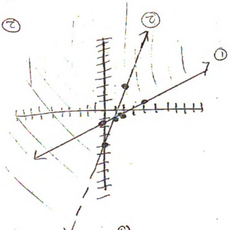
$\dfrac{-2y}{-2} \geq \dfrac{3}{-2} - \dfrac{x}{-2}$

> above

< below

① $y \geq -\frac{3}{2} + \frac{x}{2}$

② $y > 3x - 4$



$\boxed{\text{Ex 2}}$ Graph system $x \leq 0$ ①

$y \geq 0$ ②

$x - y \geq -2$ ③

③ $x - y \geq -2$

$-(-y \geq -2 - x)$

$y \leq 2 + x$

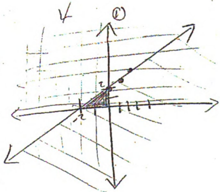


Figure 40. A Handwritten Example of the Notes Template Used My Mrs. Starns, Megan, and the Students

Again, the format of this document, which was comprised of what was to be learned and the examples to be presented, did not specifically prompt Megan to anticipate SMRs.

Within the school context Megan was accountable only to Mrs. Starns. This along with the non-collaborative nature of the mathematics education community at the school meant that Mrs. Starns was Megan's one and only resource at the school on a daily basis. Mrs. Starns norms did not directly prevent Megan from anticipating SMRs, but the nature of the context did not create the opportunities for her to anticipate that she was used to having at the university. The final section of this chapter summarizes all of the interaction findings.

5.2.4 Summary of the Factors

The zones just described represent the complex contexts and interactions that were part of this intern teachers experience. Goos (2005) presented her findings on the interactions of these zones using a Venn Diagram to show the common areas between the ZPD, ZFM, and ZPA. Figure 41 portrays the interactions between the ZFM in each context.

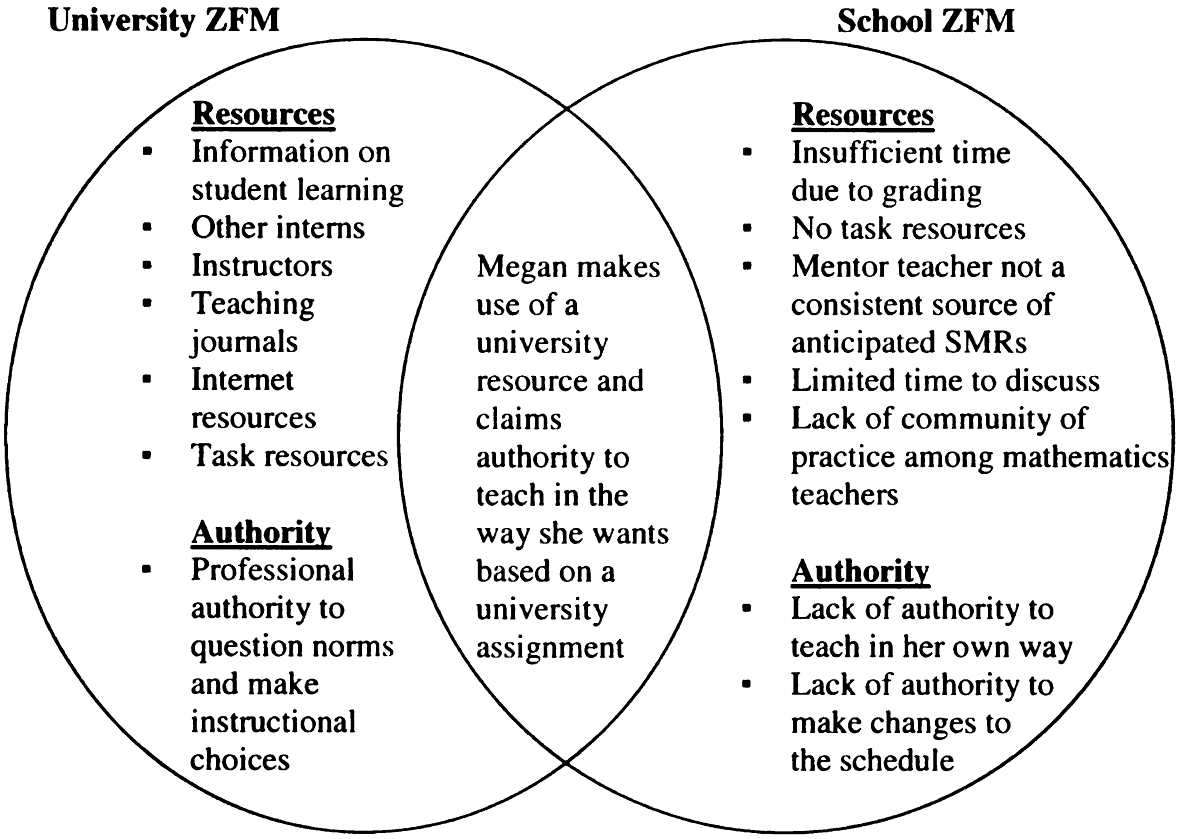


Figure 41. Venn Diagram of Relationship Between University and School ZFM

As shown in Figure 41, the only overlap between the ZFMs occurred when Megan was obligated to complete a lesson plan for a university course. Figure 42 adds to the previous figure the ZPAs in each setting.

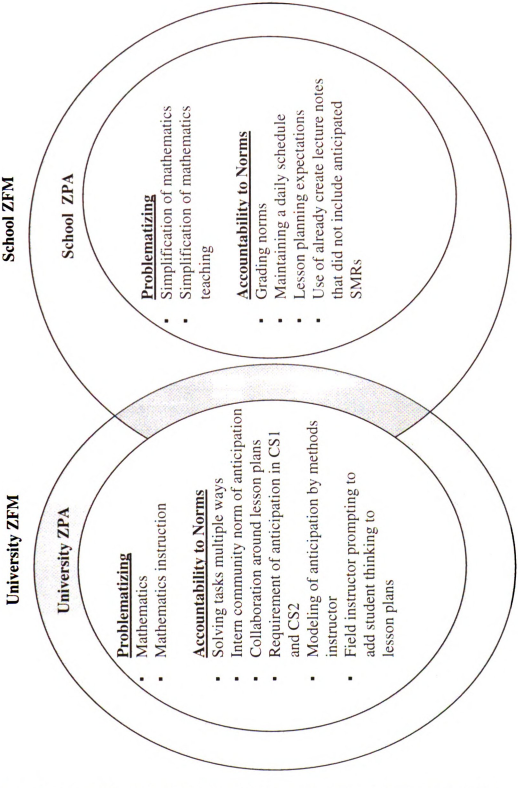


Figure 42. Venn Diagram of Relationship Between University and School ZPA

This figure shows that the promoted actions in each context, in terms of anticipating SMRs, shared no common elements. The overlap of the University ZPA into the school ZFM again represents the Cool Stuff 1 assignment in which the university lesson planning norms were applied to Megan's school lesson plans. This occurred again in Cool Stuff 2, which can also be represented as part of the overlapping space, even though university curriculum resources were not used for that lesson as they were for the Cool Stuff 1 assignment. Finally, Figure 43 adds Megan's ZPD to the Venn diagram.[19]

[19] See Chapter 2 for a complete description of the relationship between the zones in the framework.

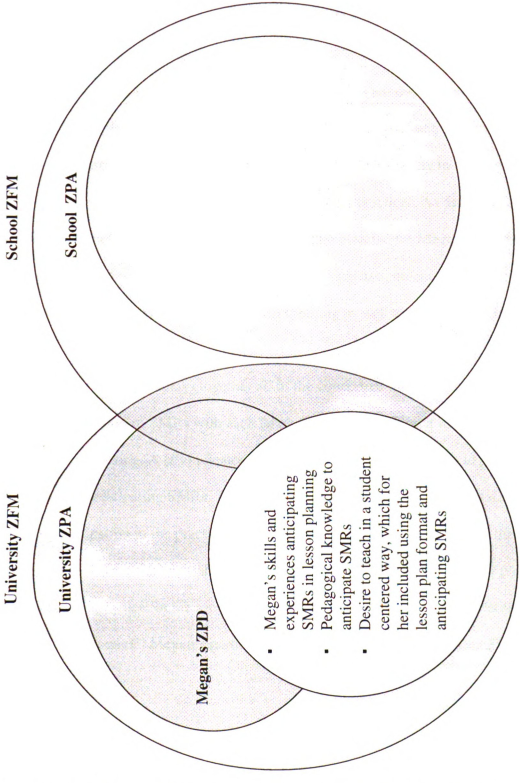


Figure 43. Venn Diagram of Relationship between University and School ZFM and ZPA and Megan's ZPD

Figure 43 shows that Megan's ZPD mostly overlaps the ZPA of the university. The area within the university ZPA but outside of Megan's ZPD represents the actions of the methods instructor to encourage the interns to "bother" their mentor teachers when needed for help in planning lessons, something Megan did not do. Other than this exception, her skills, experiences, and desires positioned her well within the range of the practices for lesson planning promoted by the university, but her day to day physical presence within the school setting determined her actual practices. As previously mentioned, the only time during the semester that the possible for Megan in the two settings intersected was during the two Cool Stuff lesson assignments. Only within this space was she free to enact her own ideas for teaching as well as those advocated by the university.

The next figure displays together all of the contextual features that related to Megan's anticipation of SMRs with each labeled according to how it related to the practice of anticipating. A (*P*) indicates that the feature promoted Megan to participate in the practice of anticipating SMRs. The other two labels indicate features that did not promote participation in the practice of anticipating SMRs. In the first case of this kind the contextual feature was neutral *(N)* to anticipating, that is, it did not directly promote or constrain the practice. In the second case, the presence of the contextual feature actively constrained *(C)* Megan's participation in the practice of anticipating SMRs.

	University	School
ZFM	Resources • Information on student learning (P) • Teaching journals (P) • Internet resources (P) • Task resources (P) • Other interns (P) • Instructors (P) Authority • Professional authority to question norms and make instructional choices (P)	Resources • Insufficient time due to grading (C) • No task resources (N) • Mentor teacher not a consistent source of anticipated SMRs (N) • Limited time to discuss (C) • Lack of community of practice among mathematics teachers (N) Authority • Lack of authority to teach in her own way (N) • Lack of authority to make changes to the schedule (N)
ZPA	Problematizing • Mathematics (P) • Mathematics instruction (P) Accountability to Norms • Intern community norm of anticipation (P) • Requirement of anticipation in CS1 and CS2 (P) • Modeling of anticipation by methods instructor (P) • Field instructor prompting to add student thinking to lesson plans (P) • Collaboration around lesson plans (P) • Solving tasks multiple ways (P)	Problematizing • Simplification of Mathematics (N) • Simplification of mathematics teaching (N) Accountability to Norms • Lesson planning expectations (N) • Use of already create lecture notes that did not include anticipated SMRs (N) • Grading norms (N) • Maintaining a daily schedule (N)

Figure 44. Experiences, Resources, and Constraints that Impacted Megan's Anticipating Practices

This figure makes plain the differences between the two settings in how the practice of anticipating SMRs was promoted and supported. Within the university context the practice of anticipating SMRs was promoted by the instructors, the other interns, course assignments, and other available resources. However, many of the features of the school context were neutral to, or did not promote, Megan's practice of anticipating SMRs. For example, Megan's mentor teacher's lesson planning expectations did keep her from anticipating SMRs, but they also did not call upon her to do so. Finally, some of the features of the school context, such as limited planning time due to an inordinate amount of grading, directly constrained her practices of anticipating SMRs by limiting her resource of time to plan lessons.

Figure 44, along with the findings from the first part of this chapter, illuminates several interesting occurrences. First, despite the fact that Megan had access to all of the resources of the university she did not make use of them except in her first Cool Stuff lesson assignment. These resources would have allowed her the opportunity to choose tasks and learn about SMRs for those tasks that she often stated she desired. Megan's own comments about wishing the school and her mentor teacher could provide her these resources indicate that perhaps she did not consider making use of the resources from the university setting in the school setting. It is important to consider along with this that Megan made little effort to seek out these resources when they were present or to attempt to assert her authority as a beginning professional in the school setting.

This scenario of wanting a certain type of resource, one that was available to her at the university, but not making use of it in the school is potentially described by a lack of intercontextuality as described by Engle (2006). In this case this would mean that

Megan did not connect the practices of the learning context, the university, to the practices of the transfer context, the school. By not doing this she did not have the opportunity to see the continued usefulness of the university resources or the practice of anticipation of SMRs in an alternative setting with alternative resources and norms.

If over generalized, Figure 44 might indicate that only the university was providing the experiences and resources needed by Megan to participate in the practice of teaching mathematics, while the school setting was providing nothing and was in fact deterring her from learning about teaching. This is not the intention of this figure, or a finding of this study. This figure only relates to the experiences and resources related to anticipating SMRs. The school setting certainly provided invaluable resources outside of anticipating in their students and by allowing Megan to come and make use of an actual classroom. Megan also had opportunities at the school to engage in other practices of teaching such as attending professional development meetings, conducting parent conferences, and working with individual students. In these and many other ways the experience was fruitful in that it allowed Megan to participate in these other types of teaching practices. What findings from this study do indicate is that despite all that was provided by the university and Megan's own desires to teach and plan lesson in certain ways, the constraints of the school setting and her own choice not to challenge these constraints, limited her participation in the practice of anticipating SMRs. The next chapter discusses the findings of this study in terms of the theoretical framework, the implications for teacher education, and future directions for research.

CHAPTER 6. DISCUSSION

Chapter 1 described the importance of field experiences in the development of preservice teachers and the need to know more about what preservice teachers learn as a result of these experiences. A large part of the work of teaching that preservice teachers do in field experiences is preparing and enacting lessons. The National Research Council (NRC) sets clear guidelines for what teachers should consider as they plan for instruction.

> [R]ather than simply listing problems and exercises, teachers should plan for instruction by focusing on the learning goals for their students, keeping in mind how the goals for each lesson fit with those of the past and future lessons. Their planning should anticipate the events in the lesson, the ways in which the students will respond, and how those responses can be used to further the lesson goals. (National Research Council, 2001, p. 425)

This study sought to shed light on how one preservice teacher planned mathematics lessons during a field experience, focusing specifically on how she anticipated her students' mathematical responses (SMRs), a practice further detailed by Stein, Engle, Smith, and Hughes (2008). Additionally, this study examined the extent to which the preservice teacher anticipated SMRs when planning her lessons, the resources that she made use of that helped her to anticipate SMRs, and the types of SMRs themselves. Finally, this study explored how the two contexts, the university and school, supported and constrained the preservice teacher in participating in this practice.

This study drew on four main areas of research literature: teacher education field experiences, knowledge for teaching mathematics, lesson planning, and anticipating SMRs. Results from this study resonate with past studies about field experiences that identified the mentor teacher and the curriculum as important contextual features in what the preservice teacher learned about teaching mathematics (Mossgrove, 2006; Vacc &

Bright, 1999). Although no data was collected on the change to the preservice teacher's knowledge for teaching mathematics as a result of the field experience, this study did highlight the sources of knowledge that this preservice teacher drew on in order to anticipate SMRs. Additionally, the preservice teacher in this study was able to identify possible SMRs prior to teaching her lessons, unlike the preservice teachers in past studies (Borko & Livingston, 1989), but most of her anticipating tended to be procedural in nature.

Findings from this study showed that the constraints of the school context and the intern's own inability to challenge these constraints limited the use of the support provided by the university context in her practice of anticipating SMRs. Megan was chosen as the participant of this study based on the quality of her lesson plans in her senior year, which were consistently designed with students in mind. Despite this, during the first semester of her internship year she showed evidence of actively anticipating SMRs in only three of the thirteen lessons she planned, two of which were prepared as an assignment for the university and required her to anticipate. Overall, her anticipation oscillated between considering that students may not see or remember the way she presented to do the mathematics and considering that the problems they may have making sense of the mathematics for themselves, with far greater frequency of the former. Additionally, she made use of relatively few resources available to her to help her anticipate SMRs.

The findings also show marked differences in the foci of the two contexts Megan worked in, the university and the school. While the university focused on communities of practice; modeled problem-solving and provided resources; and encouraged deliberate practices of planning, teaching, and reflecting, the school context represented an isolated teaching environment focused on developing teaching poise and streamlining the work of teaching. Lortie (2002) points out that situations like those in Megan's school context is not unusual in that teachers often work in "mutual isolation" and that the result is reduced opportunity "for turning to colleagues and superordinates for informed assistance" (p. 150). The situative perspective that framed this study suggests that the differences in Megan's anticipation practices may have been impacted by the differences in the contexts. The next section describes the affordances of making use of the situative perspective in this case study to investigate Megan's practices of anticipating SMRs.

6.1 Affordances of Making Use of a Situative Perspective

This study made use of the situative perspective to study the practices of one preservice teacher. As described in Chapter 2, Greeno's notion of beginning "with the framework of interactional studies and work inward" (Greeno, 1998, p. 6) was employed and thus the environments in which the preservice teacher worked as well as her own actions in these environments were investigated as part of this study. This section discusses the affordances of being able to investigate a preservice teacher's anticipating practices during a field experience from both the context and individual perspectives.

The focus on the contexts provided both background and possible explanations for the choices Megan was making in her own work. An important finding of this study was the difference between what Megan professed to want to do in her teaching and lesson planning, which aligned with university values and expectations of providing students' with open-ended experiences in which to explore and discuss mathematics, and what she actually did in the school context. This finding is especially striking given that Megan was chosen as the participant in this case study because she was so motivated to participate in and engaged with the university advocated practices during her senior year. Without knowledge of the school context, which was primarily dominated by the mentor teacher whose focus was on clear and concise presentation of examples, the contradiction between Megan's professed desires and her actions would have been without explanation. As with past researchers who have made use of the situative perspective, doing so in this study enable the researcher "to see these differences as coherent and sensible—as being integrally connected to the norms and expectations specific to the different contexts" (Peressini, Borko, Romagnano, Knuth, & Willis, 2004, p. 90).

Additional evidence from the contexts is suggestive of why the norms of the school context might have taken priority over the norms of the university context. When describing interactions with her methods course instructor about how to change her lesson plans Megan reflected that,

> When I did my Cool Stuff 1 he wanted me to really pay attention to student work and to how that could impact my teaching and how to take all those materials and think about how the kids are thinking to help them. And I tried to do that in my Cool Stuff 2. [In-Depth Interview 2, December, 2008]

This description of her methods instructor feedback is in sharp contrast to Megan's account of a conversation with her mentor teacher about making changes to the schedule and style of teaching. "She has reasons for why she does things and she will shoot them at you. So that's the hard part" [Informal Conversation, November, 2008]. These excerpts from conversations with Megan imply two things about the feedback that she receives in the different contexts. First, her lack of generalizing Dr. Rundell's comments may indicate that she viewed feedback from her methods instructor as pertaining only to the lessons she prepares for the university. This is supported by another comment Megan made about her methods instructor's expectations for her daily lesson plans, those not prepared for the university. "I think he just goes by what my field instructor expects of me so it would just be what my mentor wants" [In-Depth Interview 2, December, 2008]. Second, Megan's description of conversations with her mentor teacher about making changes to classroom practices implies that she found it difficult to talk with her about trying different ideas. This difficulty might have kept Megan from wanting to "rock the boat" in the school context. Thus, though it appeared that Megan's choices to teach and plan lessons on a daily basis were counter to her professed desires, these choices seemed more reasonable given the complex interactions taking place within the contexts.

Making use of Greeno's (1998) characterization of the situative perspective also afforded the opportunity to turn the focus of the study "inward" in order to closely investigate Megan's practices. As previously discussed, Megan's practice planning lessons for the university were drastically different from her practice planning lessons in the school. Looking inward allowed for additional investigation of the discrepancy, this time with a focus on Megan.

Within the situative perspective lack of transfer, which in this case is represented by Megan not applying university lesson planning practices to school lesson plans, is characterized by Engle (2006) as a lack of intercontextuality.

> Intercontextuality occurs when two or more contexts become linked with one another. When this occurs between learning and transfer contexts, the content established during learning is considered relevant to the transfer context ... Thus, the more related that learning and transfer contexts are considered to be, the more likely—all other things being equal—that students will transfer content between them. (Engle, 2006, p. 456)

The data suggests that there are two reasons for the lack of intercontextuality in this case. The first is the difference in styles of teaching advocated by each of the contexts, namely student-centered versus lecture-based. The second reason could have originated with Megan herself and the way that she attempted to apply university ideas in her field experience classroom.

As was described in Chapter 5, Megan appeared to link what she viewed as student-centered teaching to the use of the university lesson plan format and to anticipating SMRs.

> Yes, [anticipating SMRs is important] because in a student centered class a teacher needs to be prepared for various issues and how to provide a solution. In addition, it helps the teacher guide conversation for student learning. I try to do this by looking up articles on misconceptions, talking to my mentor teacher, and thinking of misconceptions on my own. [Lesson Planning Survey response]
>
> And the big thing with [the lesson plan format] that I really liked was that it got you to think what the students were thinking and then the questions you would want to ask them and how you'd want to answer them. [In-Depth Interview 1, September, 2008]
>
> So to me student-centered learning is doing our whole lesson plan [format]. So you would do a launch and explore where the kids are doing everything. And then you do the summary. You know, ALL that. And I want the kids to be discovering things on their own. [Informal Conversation, November, 2008]

Conversely, it appeared when teaching in a lecture-based style that Megan did not see the relevance of anticipating SMRs.

> I feel like I don't get [to think about what students are thinking] as much with lecture style things...I don't get to cause the students to think a different way or to scaffold them more in their thinking and guide their thinking. I think I'm more a dispenser. [In-Depth Interview 1, September, 2008]
>
> Today I did a lot of talking and they didn't do any work together or any student centered things. So they didn't really have questions. [Lesson 2.3 Post-Interview, November, 2008].

> I think that my literal lesson planning has changed [from last year] in that now it's just a lesson plan, lecture style lesson. I think that has changed because of my mentor and I think that has changed because of what she wants for the class. [In-Depth Interview 2, December, 2008]

These responses from Megan could indicate that for her the anticipation practices from the learning context (the university) were not relevant in the transfer context (the school). It should be noted that in neither the senior year methods course, nor the fall semester of the internship methods course was the practice of anticipating SMRs directly linked to student-centered teaching, but that discussion about practices of teaching, including anticipating SMRs, were framed by this position. Thus for Megan a potential source for the lack of intercontextuality emerged from the different styles of teaching being advocated in each setting. Past research supports this as a reason for Megan's actions. "Research indicated that enacting a desirable practice is more likely when there is coherence between the methods course and the fieldwork" (Clift & Brady, 2005, p. 319).

The second reason for the lack of intercontextuality could be related to Megan's own views of applying university-learned ideas outside of the university. Farmer, Gerretson, and Lassak (2003) describe a framework that they developed to study mathematics teachers' appropriation of ideas encountered in professional development experiences. The first, and most basic, of the three levels of appropriation is described as *Concrete activity and content.* At this level,

> teachers participating in a mathematics professional development activity appropriate content such as specific mathematical skills or concepts that they will actually teach or specific pedagogical techniques to implement in their classrooms. Furthermore, they look for specific mathematical problems, tasks or games to use with their students. Participants who appropriate at this level are focusing on the specific parallel between mathematics activity in the seminar and mathematics activities in their own classrooms. (Farmer, Gerretson, & Lassak, 2003, p. 341)

There is evidence that Megan was operating at this level as opposed to one of the higher levels in which teachers attempt to integrate ideas, tasks, and theory from seminars into their specific contexts. When asked about trying to use more open-ended activities in the spring semester Megan responded, “It's hard because my mentor does not already have those tasks available for me to use. So I would have to go out and find my own” [Lesson 3.3 Pre-Interview, December, 2008]. In addition, although Megan stated in her final interview that she never discussed lesson ideas with the other interns during the fall semester of the internship experience, in one of the Fireside chats she did ask one of the other interns to create a CD of all of the Algebra 2 activities that the other intern had from her school[20].

These findings regarding Megan’s level of appropriation resonate with previous findings about preservice teachers. Borko, Eisenhart, Brown, Underhill, Jones, and Agard (1992) studied preservice teachers teaching grade 6 mathematics.

> We found that Mrs. Daniels and the other student teachers came to place more importance on learning activities that could be directly imported to their student teaching classrooms than on verbal, theoretical, or conceptual information covered in their university coursework. (Borko et al., 1992, p. 215)

Operating at the *Concrete activity and content* level, Megan was likely unable to adapt university practices, including actively/purposefully anticipating SMRs, to her own teaching in the school. Instead she was focused on finding what she considered to be student centered tasks. Thus, Megan’s own level of appropriation potentially impacted her ability to find the intercontextuality and realize the role of active/purposeful anticipation SMRs in any teaching context.

[20] The other intern was teaching at a school that had the reputation among the interns of having superior activities and resources.

Finally, looking inward also afforded the opportunity for glimpses into the classroom, in the form of mini-cases, to see the accommodations Megan made to address what she anticipated as well as the identification of different levels of anticipated SMRs. The mini-cases showed that Megan did not always or was not always able to make appropriate accommodations within her lesson plan to address what she anticipate, although she anticipated questions or difficulties, and on rare occasion naïve conceptions, in every lesson. Dr. Rundell noticed at the beginning of the semester that connecting the anticipated SMRs to teacher moves in their lesson plans was difficult for all of the interns. This study was able to provide two in-depth pictures of an intern struggling to make this connection. Another outcome of looking inward on Megan's anticipation practices was the beginning of a discussion of different levels of anticipated SMRs. Much of Megan's anticipating focused on whether students would remember procedures that had been taught. This kind of anticipating has been present for quite some time as evidenced by the mathematical songs and mnemonics such as PEMDAS that exist to help students remember procedures that they may forget.

There was also another kind of anticipating that Megan evidenced when she considered that students might be confused if she used the word "steeper" in a different way than she had in the past. This kind of anticipating considers more carefully students understanding of concepts, versus their memory of procedures. This anticipation took place for a lesson that was somewhat different than the normal presentation of examples that took place in the school content. In this lesson Megan used a worksheet created by her mentor teacher to guide students through the graphing of various square root and cube root functions. Though the activity was rather directive, in this lesson students graphed all of the functions on their own calculators and Megan's role was to help them see how changes to the function resulted in changes to its graph. This particular activity had a slightly higher level of cognitive demand (Stein, Smith, Henningsen, & Silver, 2000) than past lessons, which only called on students to make use of the procedures with which they were presented. This might indicate that the differences in Megan's anticipating were based, at least in part, on the nature of activities within the lessons. Perhaps because this activity was less lecture-based, the anticipation was also focused on less procedural aspects of the learning. This study highlighted these differences in what can be anticipated. The next section presents the implications of the findings of this study and provides recommendations for the field.

6.2 Implications and Recommendations for the Field

This study investigated the anticipation practices of one student teacher during lesson planning in two distinct environments, a university and school context. Findings from this study have implications for mathematics teacher education programs. The next sections outline three implications from this study: (1) Promoting intercontextuality through noticing, (2) Focusing on the role of the mentor teachers, and (3) Connecting with other mathematics education communities.

6.2.1 Promoting Intercontextuality through Noticing

As discussed in the previous section, intercontextuality did not appear to exist for Megan between the two contexts, meaning she did not use what she learned about anticipating SMRs in the university setting in the school setting. This finding is an issue for teacher education programs which suggests the programs need to find ways to promote intercontextuality between the learning and the transfer contexts. Many of the experiences in Dr. Rundell's class likely contributed to the interns' ability to make this connection through the focus on the school contexts which were foregrounded in many of the class discussions and activities. Another way to do this would be for university programs to further develop preservice teachers ability to notice as described by van Es and Sherin (2002).

> Specifically, we propose three key aspects of noticing: (a) identifying what is important or note worthy about a classroom situation; (b) making connections between the specifics of classroom interactions and the broader principles of teaching and learning they represent; and (c) using what one knows about the context to reason about classroom interactions. (van Es & Sherin, 2002, p. 573)

If preservice teachers were able to make the connections and reason about interactions as van Es and Sherin describe, this would support them, and teacher educators, in framing the learning context and the transfer context as being linked. One example of how this was done in the university context was by making the teaching practices of the university instructor public. In one instance a field instructor present in the class talked to the students about the detail of Dr. Rundell's lesson plans and connected his teaching moves to his lesson plan and to particular topics already discussed in class. In addition to making their own teaching moves public, methods course instructors could ask preservice teachers to bring in video examples of their own teaching or to watch examples of other teachers teaching. Star and Strickland (2008) found that through focusing on noticing in a methods course the preservice teachers' were able to improve their ability to notice. Improving their ability to notice, including making connections and reasoning about the interactions, could help preservice teachers see the relevance of university practices in their school contexts, even if they are not immediately obvious to the preservice teachers.

The relevance of anticipating SMRs in the school context was evidenced in the first mini-case in which Megan anticipated students would struggle to visualize a plotted point in three dimensions and they did. If Megan had a more developed ability to notice, she might have recognized the importance of anticipating SMRs as well as her own failure to address what she had anticipated, both practices that were advocated by the university. In doing so she might have further linked the practice to the school context and also learned a powerful lesson and made a more deliberate effort to addressed what she anticipated in her lessons in the future.

6.2.2 Focusing on the Role of Mentor Teachers

The second implication for teacher education focuses on the role of the mentor teacher. Although the school context provided Megan opportunities and experiences that the university could not, many facets of the context would not be considered ideal by many teacher educators. In fact in this case, particular aspects of the experience, including the mentor teacher and the lack of a greater school mathematics community, limited Megan's ability to participate in a practice promoted by the university. As discussed in Chapters 4 and 5 Megan's mentor teacher held particular views of teaching students and her role as a mentor teacher. Feiman-Nemser (2001) addresses how the views of a mentor teacher can impact the experience of the preservice teachers.

> [M]entoring has the potential to foster powerful teaching and to develop the dispositions and skills of continuous improvement. At the same time, mentors may also perpetuate standard teaching practices and reinforce norms of individualism and noninterference. How mentors define and enact their role, what kind of preparation and support they receive, whether mentors have time to mentor, and whether the culture of teaching reinforces their work all influence the character and quality of mentoring and its influence on novices' practice. (Feiman-Nemser, 2001, p. 28)

In Megan's case, Mrs. Starns did reinforce some practices that were counter to what the university intended, which because of her significant role may have had an indelible impact on Megan's development as a teacher, and specifically a planner of lessons. These practices included lesson planning expectations that focused Megan on her own thinking, representations, and delivery as opposed to students' reactions as well as not following the recommendations of the university in terms of not asking Megan to do extra grading, making regular time to discuss lesson plans, and giving her control over her own teaching in the focus class.

Feiman-Nemser (2006) introduces the notion of *educative mentoring* in describing the actions of "an exemplary support teacher." She describes educative mentoring in the following way:

> Educative mentoring rests on an explicit vision of good teaching and an understanding of teacher learning. Mentors who share this orientation attend to beginning teachers' present concerns, questions, and purposes without losing sight of long-term goals for teacher development. They interact with novices in ways that foster an inquiring stance. They cultivate skills and habits that enable novices to learn in and from their practice. They use their knowledge and expertise to assess the direction novices are heading and to create opportunities and conditions that support meaningful teacher learning in the service of student learning. (p. 18)

In this case the mentor teacher saw her role quite differently than what was described by Feiman-Nemser and her actions imply that she held different views of good teaching than the university or those that Megan professed. Building this shared vision of good teaching is a complex and difficult issue worthy of consideration. Mrs. Starns' views are not indicative of the fact that she, or any other mentor teacher with differing views, does not have the best intentions to support their interns. It does mean that if universities desire the participating mentor teachers to be educative mentors, as Feiman-Nemser describes, they may need to develop and support mentor teachers in learning to support their interns in this way.

Feiman-Nesmer (2001) discusses specific activities in the learning experiences of the exemplary support teacher in her article. Central to these activities was this teacher's participation in a professional learning community in which he shared his experiences, received feedback, and worked with other support teachers. This community took place within a two-year program, implying that one needs an extended period of time to learn to be an educative mentor. Finally, a specific finding from this study indicates these professional learning communities would need to support mentor teachers in relinquishing some of their authority to the preservice teachers in their classrooms so that preservice teachers can explore and participate in teaching practices that reflect their own beliefs about teaching.

6.2.3 Connecting with Other Mathematics Education Communities

Findings from this study indicate that the community of practice described in the syllabus was created in the methods course:

> The blog is designed to accommodate narrative accounts of what's happening in our classes, so that we can all understand one another's classroom contexts. This fosters a sense of **a community of practice**, where we engage with one another around issues of teaching. [Methods Course Syllabus]

However, this type of community did not appear to exist in the school context. The existing relationships of the mathematics teachers in the school context meant that for Megan her mentor teacher likely represented the entire mathematics community in the school. Despite Megan's direct access to this community, she did not take full advantage of her mentor teacher's knowledge or experience in anticipating SMRs. A possible reason for this is that she did not know how to engage her mentor teacher in conversations that allowed her access to this knowledge and experience. This might also have been the result of Mrs. Starns advice to "know your content," implying that that was something for Megan to work through and know on her own, and thus not inviting conversation that problematized the content or the teaching of the content.

Meijer, Zanting, and Verloop (2002) addressed this particular issue by asking preservice teachers in several different content to use a concept mapping exercise and stimulated recall interview to elicit their mentor teacher's practical knowledge of teaching. They found that the concept maps provided the preservice teachers' access to their mentor teacher's ideas underlying their teaching and the ways in which the ideas were related and the stimulated recall interviews allowed the preservice teacher access to the mentor teacher's reasons behind specific teaching actions. These types of activities and others could help preservice teachers gain access to the knowledge and experiences of their mentor teachers and perhaps even other teachers in their school professional learning community.

Megan also did not make use of resources provided by the larger mathematics education community that could have supported her in anticipating SMRs. In her responses to the Lesson Planning Survey, Megan indicated that in her senior year, when she taught four lessons in a classroom and two lesson in lab, she almost always read professional articles about how students might engage with the content she was about to teach in planning lessons. This was one of the many factors that distinguished her as ideal and a participant for this study. Despite this senior year practice, findings from this study indicate that she never did this in preparing her daily lessons during the fall semester of her internship year. Evidence also suggests that her mentor teacher also did not make use of these resources.

These findings indicate the need to continue to support preservice teachers to find ways to make use of the resources available from the greater mathematics education community. The teaching journals of the National Council of Teachers of Mathematics provide information about student learning based both research and the experiences of other teachers. Experience working with in-service teachers indicates that teachers sometimes feel that these resources do not apply to their contexts or their students. Evidence from conversations between Megan and her mentor teacher support the fact that her mentor teacher felt this way, at least about the university. Based on a debrief conversation between Megan and her field instructor, Megan went back to her mentor teacher and questioned her about some of her practices that Megan was expected to adopt in her teaching. As one example she asked her mentor teacher why the students played games during class and why these games were not math games. The mentor teacher responded to this by rolling her eyes and stating that the field instructor had no idea why she did it. Further, she went on to say "honestly her criticism of me will not affect what I do in my class" [Informal Conversation, Lesson 1.3 Observation]. Megan's stated reason for not making use of professional articles was a lack of time, based on the fact that she had so much grading to do. Teacher education programs need to further support preservice teachers in seeing the relevance of these resources in their own classrooms so that they see the value of using them, even when it means taking extra planning time.

Teacher education programs need to identify further methods for supporting preservice teachers in connecting and making use of resources outside of the university so that they can carry those skills into their future schools and help to create professional learning communities in those contexts. As Dr. Rundell wrote about in the methods course syllabus,

> Many of our former interns who are now teaching in schools report that the thing they miss most from the internship is the sustained opportunity to meet with their colleagues and talk about their teaching. The opportunity to share your thinking and have your ideas challenged by others is a critical part of developing as a

> teacher, and an experience that is often hard to come by in the normal course of the school day. This year, we will help you develop the *skills* for learning from your colleagues, and, perhaps more importantly, the *disposition* to do so, so that you can seek out or create these kinds of opportunities throughout your career. [Methods Course Syllabus]

An example of a resource and a professional learning community can be found in the work of Herbal-Eisenmann and Cirillo (2009) who present stories from teachers about their own learning about their mathematics teaching as part of participation in a larger professional development program. The next section describes directions for future research based on the findings of this study.

6.3 Future Research

While this study succeeded in shedding light on a particular case of a preservice teacher anticipating SMRs, the findings also point to areas of need for future research. The following sections detail the next steps in this line of inquiry for the researcher.

6.3.1 Investigating Necessary Conditions for Preservice Teachers Anticipating SMRs

Findings from this study indicate that the school context negatively influenced Megan's practices of anticipating SMRs. Future research should focus on identifying the conditions needed in a school context to promote anticipating. These studies might take the form of comparisons. Megan was purposefully selected for this study because she showed ability and motivation to anticipate SMRs in her senior year methods courses. Future research might investigate the practices of a preservice teacher who did not show ability and motivation to anticipate SMRs and was paired with a mentor teacher that both expected and modeled the anticipation of SMRs in their lesson planning. Studies comparing preservice teachers' anticipation practices might also include field experience classrooms with different styles of mathematics teaching. For example, do classrooms in which students actively and frequently participate and come up with a variety of solution strategies encourage preservice teachers to anticipate SMRs? An additional feature of the school context that should be investigated for its impact on preservice teachers is the availability of resources that provide information to help the preservice teachers to anticipate. These resources include curriculum materials and the mathematics teaching community present at the school. Given the importance of field experiences, future research needs to focus on identifying the features of school contexts that are necessary and have the greatest impact on preservice teachers' anticipation practices.

6.3.2 Investigating the Role of Experience and Expertise

There is no question that experienced and expert mathematics teachers know different things and teach in different ways than novice teachers. Brown and Borko (1992) reviewed studies that identified the specific differences between expert and novice mathematics teachers. They found that:

> Expert teachers displayed more pedagogical knowledge, content knowledge, and pedagogical content knowledge...their conceptual systems, or cognitive schemata, for organizing and storing this knowledge are more elaborate, interconnected, and accessible...and are more efficient than novices in their processing of information during both planning and the interactive phases of teaching. (p. 213)

This knowledge and experience might be viewed as useful in the practice of anticipating SMRs. However, despite these differences, Borko and Livingston suggest from the findings of their study that direct experience teaching the content would support a teacher in anticipating SMRs more than their expertise and more general experience.

> Several of the difficulties the novice teachers encountered, such as the time-consuming nature of their planning and the inability to anticipate student problems, are difficulties encountered by most teachers the first time they teach a course or body of knowledge. Any teacher will think and act like a novice, to some extent, the first time he or she attempts to teach a particular body of knowledge. (Borko & Livingston, 1989, p. 489)

Future research should investigate the role of teaching experience and expertise in anticipating SMRs. Important in this type of investigation is the criteria for the identification of expert teachers. The expert teachers in the studies reviewed by Brown and Borko (1992) were identified as experts in a variety of ways. In one study, expert teachers were identified as teachers having five or more years of teaching experience, while another defined expert teachers as those whose student test scores showed consistent growth. Finally, one studied characterized expert teachers as mentor teachers who had been recommended by building administrators. It will be important for future research in this area to identify "expert" teachers as those with different knowledge, as described by Brown and Borko (1992), than the novice teachers in the study. Also crucial for this type of study would be the choice of participants who must regularly participate in the practice of anticipating SMRs. Using this, future research needs to investigate the differences in what is anticipated and the anticipation practices of novice teachers, expert teachers without experience teaching particular content, and expert teachers with experience teaching particular content. This comparison will allow for a close look at the practice of anticipation and enable researchers to tease out the influence of different types of experience and knowledge on the practice of anticipating.

6.3.3 Investigating the Role of Content Knowledge

A final area of focus for future research is the role of content knowledge in anticipating SMRs. The current research framework based the practice of anticipating SMRs on teachers' knowledge of content and students, a primary element of pedagogical content knowledge. Hill, Ball, and Schilling (2008) define knowledge of content and students as "knowledge of content intertwined with knowledge of how students think about, know, or learn this particular content" (p. 375). Future research needs to investigate the role of other types of knowledge for teaching mathematics, specifically content knowledge, in mathematics teachers' practices of anticipation.

Findings from the current study suggest that a lack of content knowledge might prompt teachers to anticipate SMRs. In the Lesson Planning Survey the majority of the preservice teachers responded that anticipating SMRs was an important practice for teachers in order to be prepared to teach lessons. Thus feeling unprepared due to lack of content knowledge might cause a teacher to anticipate SMRs even more than they normally would.

A different perspective suggests that lack of content knowledge might prevent a teacher from anticipating because it may prompt them to change how they teach the mathematics, and therefore the way that they plan their lessons. As Leinhardt (1993) explains, "as the subject matter becomes more complex teachers tend to reduce their attention to the individual learner and his or her needs or responses" (1993, p. 6). Future studies need to investigate the role of mathematical content knowledge, as another type of knowledge needed to do the work of teaching, in what teachers anticipate and the anticipating practices in which they participate.

Appendices

Appendix A.

Weekly Mathematics Problem Discussion Guidelines

You are responsible for preparing a class discussion of the homework problem assigned to you. In most cases, the problems will be given as homework for the class to have ready by the assigned date. One of the pair will be responsible for the discussion, which should take no more than 30 minutes. The other will organize a 15-20 minute discussion about the misconceptions students may bring to the mathematics in the problem. Managing time in a class is important and to help you learn about pacing, we will signal you when you have five minutes left. The instructors will be responsible for making the problems available to the class and in most cases, the problems will be posted on Angel.

The "homework time" can be conducted using a variety of instructional strategies – use your imagination and choose a strategy that seems to make sense for the problem. To help you think of possible approaches, we ask that you meet with one of the instructors prior to the class to process how each of the two parts might be conducted and to send a short description of how you intend to proceed to the instructors on the Monday preceding the problem presentation. You should include the mathematical objective you want to make, the questions you want to ask, things you want the class to do, how you are going to record any discussion, and the summary statement you will make. Your description should include any materials you might need – flip chart paper, post it notes, graphing calculators, markers, overhead transparencies, etc.

One of the key ideas in this set of algebra problems is the use of a multiple strategies to help students develop different ways to think about doing mathematics. It is important to have students share their work and to talk about the strengths and weaknesses of the different approaches. Try to think of ways to anticipate responses from the class and how you will process the sharing to maximize the time you have for discussion. Pay attention to the pacing (remember the 30 minutes).

Appendix B.

Lesson Planning Format

Lesson Logistics and Setting

Unit Topic:

- Previous Lesson Topic:

- Current Lesson Topic:

- Next Lesson Topic:

Lesson Objectives:

The learner will know/understand/be able to ...
(choose one and complete the sentence)

- Standards Addressed:

How will I know students have met the objectives?

Lesson Activities (On next page/Attach any handouts you will use)

Homework:

Lesson	**Students are working …** *(details about how students are configured, what work they are doing and how they are recording their work)*	**Anticipated Student Thinking/ Questions**	**Teacher Moves**
Launch			
Explore – Description of Task(s)			*Exact question that you will pose to students to begin the exploration.*
Summarize/ Share and Discuss	*Presentation mode – Sharing solutions, teacher-led discussion, student led discussion, etc.*		*What will you say or do to set up the discussion of the big math ideas?*
Summary Statement: *(May change based on what actually happens in class)*			

Appendix C.

Mentor Teacher Initial Interview Protocol

- This is (name of interviewer) interviewing (name of interviewee) on (date). This is an initial interview.
- Thank you for participating in the interview today. The purpose of the interview is for me to gain insight into how you view certain aspects of the mathematics education environment at (name of school).
- I'd like to talk now about the school.
    - Tell me about (name of school).
    - What are the students like?
    - What classes do you teach?
        - How long have you been teaching each of the classes?
- Is this your first time being a mentor?
- What do you know about Megan's courses at MSU?
- I'd like to talk more now about Megan. What will a typical day look like for Megan?
- Could you talk about how you envision the year proceeding with Megan?
    - What do you expect from Megan as your intern?
        - In terms of lesson planning?
        - Will you plan lessons together? Why or why not?
        - In terms of teaching?
        - What other kinds of expectations do you have?
    - In what ways do you envision helping Megan meet those expectations?

- How would you describe the philosophy of the mathematics department in your school?
    - How is it similar to or different from what happens in your classroom when you are teaching?
    - Is there anything else you'd like to say about the math department at your school?
- What interactions do you have with other math teachers in your school?
- How are decisions made about what gets taught?
- Is there anything else you'd like to say about the environment at (name of school)?

General prompts for elaboration on ideas that the teacher brings up:

- Would you say more about [*use teacher's own words here*]?
- Would you say more about what you mean by [*use teacher's own words here*]?
- Would you give me an example [of that/what you mean by *teacher's own words*]?
- *If the teacher uses a word or phrase that you're not familiar with:* I'm sorry, I'm not familiar with what _________________ is. Would you tell me more about it?

Appendix D.

Field Instructor Initial Interview Protocol

- How do you see your role as field instructor?
- What are your goals for the interns that you will work with this year?
    - *If some goals related to lesson planning are mentioned further prompt,* Can you tell me more about your goals with respect to what the interns will learn about lesson planning from working with you during this experience?
    - *If lesson planning is not mentioned,* Can you tell me about any goals that you have with respect to what the interns will learn about lesson planning from working with you during this experience?
- What are your expectations for the lesson plans that Megan writes?
- What do you know about Megan's internship school?
- What do you know about Megan's cooperating teacher?
- How do you plan to work with Megan's cooperating teacher to achieve the goals you mentioned?
- How do you plan to work with Megan, either individually or with a group of interns, to meet the goals and expectations you mentioned?

General prompts for elaboration on ideas that the teacher brings up:

- Would you say more about [*use field instructor's own words here*]?
- Would you say more about what you mean by [*use field instructor's own words here*]?

- Would you give me an example [of that/what you mean by *field instructor's own words*]?
- *If the field instructor uses a word or phrase that you're not familiar with:* I'm sorry, I'm not familiar with what ________________ is. Would you tell me more about it?

Appendix E.

Methods Instructor Initial Interview Protocol

- This is (name of interviewer) interviewing (name of interviewee) on (date). This is an initial interview.
- Thank you for participating in the interview today. The purpose of the interview is for me to gain insight into how you view certain aspects of mathematics education environment at (name of school).
- What are your goals for the methods course?
    - *If some goals related to lesson planning are mentioned further prompt,* Can you tell me more about your goals with respect to what the interns will learn about lesson planning from participating in the course?
    - *If lesson planning is not mentioned,* Can you tell me about any goals that you have with respect to what the interns will learn about lesson planning from participating in the course?
    - *If it is not yet been mentioned,* How does this course relate to the field experience?
- What opportunities do interns have to work cooperatively as part of this course?
- What are the major course assignments for the fall semester?
- How many lesson plans will be turned in for grading or feedback for this course?
    - What are your general requirements (not specific to any given assignment) for lesson plans?
    - Do you plan to grade lesson plans that are turned in? If so, how do you grade them? If not, why not?

  - Do you plan to provide feedback on lesson plans that are turned in? If so, what kind of feedback do you provide? If not, why not?
- How will you introduce the idea of anticipating students' mathematical responses to the class?
  - When will you introduce anticipating?
  - What resources will you direct interns to use to anticipate?
  - What resources are generally available to interns to use to anticipate? Where are these available?
  - Are there aspects of assignments either in class or out of class, other than lesson planning, that may support the interns in learning to anticipate SMRs?
- Is there anything else that you would like to tell me about the methods course?

General prompts for elaboration on ideas that the teacher brings up:

- Would you say more about [*use instructor's own words here*]?
- Would you say more about what you mean by [*use instructor's own words here*]?
- Would you give me an example [of that/what you mean by *instructor's own words*]?
- *If the instructor uses a word or phrase that you're not familiar with:* I'm sorry, I'm not familiar with what _________________ is. Would you tell me more about it?

Appendix F.

Lesson Planning Survey

Part 1

[To be administered separately from Part 2]

Imagine that you are back in your senior year methods course and you are planning a lesson to teach in your field experience classroom. What would you do to plan this lesson? Make a numbered list that details the steps you would take to prepare this lesson before you teach it. Be as specific as possible.

Part 2

1. When I planned a lesson in my senior year methods course I…

	Always	Almost Always	Sometimes	Hardly Ever	Never
a. made sure I had a good night of sleep so that I could think clearly about the lesson					
b. worked the mathematical task or solved the problem(s) I planned to give to students					
c. arranged a one-on-one meeting with an instructor to discuss my ideas about the lesson plan					
d. consulted the teacher guide for possible areas where students might struggle or solution strategies they might come up with					

	Always	Almost Always	Sometimes	Hardly Ever	Never
e. read articles about how students might engage with the content I was about to teach					
f. videotaped myself teaching the lesson and then watched to see what I could do better					
g. asked my mentor teacher about their experiences teaching the content					
h. wrote a script indicating all the words I wanted to say in the lesson					
i. thought about the learning needs of particular students in the class (i.e. Will this lesson make sense for Shannon in my 3rd period class?)					
j. planned how I would use the blackboard during the lesson					

2. Consider parts **a** through **j** in question 1 above. Do you plan to do any of these activities differently in your upcoming internship year than you during your senior year field experience? State which ones you would do differently and why. If you would do the same things you did during your senior year explain why.
3. How do you choose tasks, activities, or problems to teach the mathematics of your lessons? What kinds of tasks, activities, or problems do you tend to choose? Why do you choose these?

4. When you present examples to students in class to teach the lesson, how do you choose what examples to use?

5. (a) The practice of carefully considering students possible solution strategies, naïve conceptions (misconceptions), difficulties, and questions while planning your lessons is encouraged by your teacher preparation program. Why do you think the program encourages this?

(b) Do you agree that this is an important practice? Why or why not? If you do, how do you try to do this?

6. Have you taught a lesson about angle measure before? ❑ Yes ❑ No

7. Have you discussed teaching angle measure in an education class before? ❑ Yes ❑ No

8. Imagine that you are going to teach a lesson in which your goal is for students to learn to measure angles with a protractor. What are some possible misconceptions students might have about the concept of angle measure?

What are some possible problems students might have using a protractor?

What other difficulties, misconceptions, or possibly correct ideas do you think students might have about angle measure?

Appendix G.

In-Depth Lesson Interview 1 Protocol

(Prior to the interview, the preservice teacher will complete the Lesson Planning Survey. In addition she will be asked to bring a completed lesson plan to the interview that she has prepared for her focus class but not yet taught.)

INTRODUCTION.

This is (YOUR NAME) interviewing (TEACHER'S NAME) on (DATE) and this is the first in-depth interview.

Thank you for participating in this interview. The purpose of this interview is for me to understand your current thinking on lesson planning.

Time when Interview was started:

PART 1. Semi-structure interview based on the intern's lesson plan[21].

- Could you walk me through the plan you have come up with?

Lesson Background

- What are your goals for the lesson? What mathematical content and processes do you hope students will learn from their work on this task?
- What task or activity is the basis for this lesson?
- Why did you choose this specific task?
- How will this task or activity help students meet the objective?
- How will you group students to participate in this activity?
    - o Why did you choose this grouping?

[21] This interview has been adapted from an assignment used by Mossgrove (2006)

- What will your role be during this lesson?
- How does this lesson connect to what came before and build toward what comes after mathematically?

Account of Lesson Planning Process

- What were the steps that you took in planning the lesson for today?
    - What resources did you consult? (mentor teacher, other preservice teachers, curriculum materials, journal articles, methods course instructor, field instructor)
        - Why did you search for those resources?
        - What did you learn from these resources?
            - How did that impact your lesson?
    - If none, why not?
- Did anything happen in class yesterday or recently that made you change your lesson for today?

Selecting and Setting up a Mathematical Task

- In what ways does the task build on students' previous knowledge? What definitions, concepts, or ideas do students need to know in order to begin to work on the task?
- Have you solved the task yourself?
- What are all the ways the task can be solved?
    - Which of these methods do you think your students will use?
    - What misconceptions might students have?
    - What errors might students make?

- *If the preservice teacher included anticipated student responses ask*

  I noticed that you have included student (strategies, questions, misconceptions, difficulties).

  - Why did you include them?
  - How did you think of them? What resources did you use?
  - If you could have had resources available to help you think about student responses what would you have wanted?

  If the preservice teacher did not include anticipated student responses ask

  I noticed that you have not included student (strategies, questions, misconceptions).

  - Why did you choose not to include them?
  - If you were going to include student strategies, questions and misconceptions in this lesson plan how would you go about figuring out what they might be?
- How will you ensure that students remain engaged in the task?
  - What will you do if a student does not know how to begin to solve the task?
  - What will you do if a student finishes the task almost immediately and becomes bored or disruptive?
  - What will you do if students focus on non-mathematical aspects of the activity (e.g., spend most of their time making a beautiful poster of their work)?
- What are your expectations for students as they work on and complete this task?

- What resources or tools will students have to use in their work?
- How will the students work -- independently, in small groups, or in pairs -- to explore this task? How long will they work individually or in small groups/pairs? Will students be partnered in a specific way? If so in what way?
- How will students record and report their work?

- How will you introduce students to the activity so as not to reduce the demands of the task? What will you hear that lets you know students understand the task?

Supporting Students' Exploration of the Task

- As students are working independently or in small groups:
  - What questions will you ask to focus their thinking?
  - What will you see or hear that lets you know how students are thinking about the mathematical ideas?
  - What questions will you ask to assess students' understanding of key mathematical ideas, problem solving strategies, or the representations?
  - What questions will you ask to advance students' understanding of the mathematical ideas?
  - What questions will you ask to encourage students to share their thinking with others or to assess their understanding of their peer's ideas?

Sharing and Discussing the Task

- Which solution paths do you want to have shared during the class discussion in order to accomplish the goals for the lesson?
    - Which will be shared first, second, etc.? Why?
    - In what ways will the order of the solution paths help students make connections between the strategies and mathematical ideas?
- What will you see or hear that lets you know that students in the class understand the mathematical ideas or problem-solving strategies that are being shared?
- How will you orchestrate the class discussion so that students:
    - make sense of the mathematical ideas being shared?
    - expand on, debate, and question the solutions being shared?
    - make connections between their solution strategy and the one shared?
    - look for patterns and form generalizations?
- What extensions to the task will you pose that will help students look for patterns, make connections or form a generalization?
- Is there anything else you would like to say about your lesson plan?

PART 2. Semi-structured interview based on Secondary Mathematics Intern Pre-Field Experience Survey responses

Now that we have talked about how you planned a particular lesson I would like to discuss some of your responses to the survey which told me more about how you plan lessons in general. I am going to ask you some questions about your responses on that survey.

Steps in Writing a Lesson Plan

Reference the list she made for Part 1 of the survey

- Can you say more about (anything that is unclear or interesting)?
- What do you mean by (term they used)?
- *If doing the task or activity is not listed but is included in question 1 from Part 2 ask*
    - Are there times when you do the tasks or activities before you teach and times when you do not?
        - (If yes) Under what conditions do you choose to do the task or activity?
        - (If no) Why do you think you did not list it as one of the steps in your lesson planning process?
- *Ask similar questions for (a) consulting the teacher guide, (b) reading articles, and (c) asking the mentor teacher.*

Questions about Responses to Part 2

(General)

- Can you say more about (anything that is unclear or interesting)?
- What do you mean by (term they used)?

(Question 2)

- Can you explain more about why you will do ___ activity differently?

(Question 8)

- How do you think the problems, misconceptions, and ideas you have identified will impact the teaching of a lesson about angle measure?
- Ok, great. Thank you very much for participating in this interview.

Interview end time:

Appendix H.

Pre- and Post-Lesson Interview Protocol

PRE-LESSON INTERVIEW

(Ask that she bring all materials to interview including lesson plan, notes, activities and tasks)

Lesson Background

- What are your goals for the lesson? What mathematical content and processes do you hope students will learn from their work on this task?
- What task or activity is the basis for this lesson?
- Why did you choose this specific task?
- How will this task or activity help students meet the objective?
- How will you group students to participate in this activity?
    - Why did you choose this grouping?
- What will your role be during this lesson?
- How does this lesson connect to what came before and build toward what comes after mathematically?

Account of Lesson Planning Process

- What were the steps that you took in planning the lesson for today?
    - *If not mentioned as part of the steps,* Did you complete this task yourself?
    - What resources did you consult? (mentor teacher, other preservice teachers, curriculum materials, journal articles)
        - Why did you search for those resources?
        - What did you learn from these resources?

- How did that impact your lesson?

  - If none, why not?

Focusing on Anticipating

Refer to the lesson plan and other materials is anticipation has been done in those documents

- Do you think that there is more than one way students could approach/solve the task or activity?
  - (if yes) What are they?
  - (if no) Why not?
- What questions do you think students might have during this task or activity?
- What difficulties do you think students might have during this task or activity?
- What misconceptions do you think might arise?

General Anticipating

- How do you think the students in this class will receive the task/activity?
- Did your teaching or student responses yesterday or earlier this week have any impact on your lesson planning?

POST-LESSON INTERVIEW

- Could you reflect on the lesson and tell me how you think it went?
- What was the student reaction to the lesson?
- Do you think the students accomplished the objective(s) you set forth?
- What happened that surprised you?

- Will you change anything about what you were going to do tomorrow as a result of what happened today?
    - If so, what?

Appendix I.

In-Depth Lesson Interview 2 Protocol

(Prior to the interview, the intern will be asked to bring a completed lesson plan to the interview that she has prepared for her focus class but not taught yet.)

INTRODUCTION.

This is (YOUR NAME) interviewing (TEACHER'S NAME) on (DATE) and this is the second in-depth interview.

Thank you for participating in this interview. The purpose of this interview is for me to understand your current thinking on lesson planning. There will be three parts to this interview.

Time when interview was started:

PART 1. Semi-structured interview about what the preservice teacher thinks should be in a lesson plan

- For the first part of the interview, I'd like you to take a minute to write down the things you believe you should think about when planning a mathematics lesson, or what you would include in a lesson plan for a mathematics class. Then I'm going to ask you to tell me about them.

(Give the teacher about a minute or two to write down some thoughts – keep the recorder running, the purpose is to allow a brief moment for individual think time before they have to start talking).

- Ok. I'd like for you to tell me about the things you believe you should think about when planning a mathematics lesson.

Use the general probes below to offer the preservice teacher an opportunity to provide more specificity or clarify their descriptions.

- Can you say more about (item that is unclear or brief)?
- What do you mean by (term they used)?
- Why did you include (term they used)?

Probe into differences between the preservice teachers initial numbered list from the survey to her response to this prompt, specifically differences related to anticipating students' mathematical responses.

PART 2. Discussing the teacher's lesson planning practices during the first semester of the internship

- For the second part of the interview, I'd like to ask some questions that relate to your lesson planning in general. I'd like you to talk about the things that influence your planning.
- What role does your textbook or curriculum play in your planning?
    - How do you use your textbook or curriculum when you plan?
    - Does the textbook or curriculum influence your planning in any way? *If so*, In what ways?
    - Do you use your textbook to help you anticipate students' mathematical responses?
- What role does your mentor teacher play in your planning?

- What are your mentor teacher's expectations for your lesson plans?
    - Do you discuss your lesson plans with your mentor teacher?
    - Have you planned lessons together?
    - What kinds of things have you discussed with your mentor teacher, with respect to lesson planning?
    - Has your mentor teacher shared experiences with you that have helped you anticipate students' mathematical responses when you plan?
    - Has your mentor teacher helped you find resources to anticipate students' mathematical responses? If so, what kinds of resources?
- What role do the other interns play in your planning?
    - Do you discuss your lesson plans with other interns?
    - Have you planned lessons together?
    - What kinds of things have you discussed with other interns teacher, with respect to lesson planning?
    - Have other interns shared experiences with you that have helped you anticipate students' mathematical responses when you plan?
    - Have other interns suggested resources to anticipate students' mathematical responses? If so, what kinds of resources?
- What role does your field instructor play in your planning?
    - What are your field instructor's expectations for your lesson plans?
    - Do you discuss your lesson plans with your university supervisor?
    - Have you planned lessons together?
    - What kinds of things have you discussed with your university supervisor,

with respect to lesson planning?

  - Has your field instructor shared experiences with you that have helped you anticipate students' mathematical responses when you plan?
  - Has your field instructor helped you find resources to anticipate students' mathematical responses? If so, what kinds of resources?
- What role does your methods course play in your planning?
  - What are your methods instructor's expectations for your lesson plans?
  - Do you discuss your lesson plans with the instructor of this course either one-on-one or in class?
  - What kinds of things have you discussed in your methods course, with respect to lesson planning?
  - What elements of the methods course have helped you find resources to anticipate students' mathematical responses?
  - In what ways are the lesson plans you provide for your university supervisor and methods course similar and different from those you usually produce?
- What other things influence your planning?

Move on only after teachers have offered as many factors as they can.(these could include such things as: time constraints (either in the time they have to devote to planning or in the time they have to teach something), things they are learning/doing in their teacher education program, their beliefs about what it means to learn and do mathematics and about students, resources available, parents, students, etc).

- Do you believe your planning has changed in any ways, over the course of this semester?

If yes, then

- o Can you describe the ways in which your planning has changed?
- o Are there any other ways in which you believe your planning has changed?

If no, then

- o Why not?
- o Were there any areas that you thought about changing but did not?

- Is there anything else you would like to say about your lesson planning?

PART 3. Semi-structure interview based on the intern's lesson plan[22].

- Could you walk me through the plan you have brought with you?

Lesson Background

- What are your goals for the lesson? What mathematical content and processes do you hope students will learn from their work on this task?
- What task or activity is the basis for this lesson?
- Why did you choose this specific task?
- How will this task or activity help students meet the objective?
- How will you group students to participate in this activity?
    - o Why did you choose this grouping?
- What will your role be during this lesson?

[22] This interview has been adapted from an assignment used by Mossgrove (2006)

- How does this lesson connect to what came before and build toward what comes after mathematically?

Account of Lesson Planning Process

- What were the steps that you took in planning the lesson for today?
    - What resources did you consult? (mentor teacher, other preservice teachers, curriculum materials, journal articles, methods course instructor, field instructor)
        - Why did you search for those resources?
        - What did you learn from these resources?
            - How did that impact your lesson?
    - If none, why not?
- Did anything happen in class yesterday or recently that made you change your lesson for today?

Selecting and Setting up a Mathematical Task

- In what ways does the task build on students' previous knowledge? What definitions, concepts, or ideas do students need to know in order to begin to work on the task?
- Have you solved this task yourself?
- What are all the ways the task can be solved?
    - Which of these methods do you think your students will use?
    - What misconceptions might students have?
    - What errors might students make?

- *If the preservice teacher included anticipated student responses ask*

  I noticed that you have included student (strategies, questions, misconceptions, difficulties).

  - Why did you include them?
  - How did you think of them? What resources did you use?
  - If you could have had resources available to help you think about student responses what would you have wanted?

  If the preservice teacher did not include anticipated student responses ask

  I noticed that you have not included student (strategies, questions, misconceptions).

  - Why did you choose not include them?
  - If you were going to include student strategies, questions and misconceptions in this lesson plan how would you go about figuring out what they might be?

- How will you ensure that students remained engaged in the task?
  - What will you do if a student does not know how to begin to solve the task?
  - What will you do is a student finishes the task almost immediately and becomes bored or disruptive?
  - What will you do if students focus on non-mathematical aspects of the activity (e.g., spend most of their time making a beautiful poster of their work)?
- What are your expectations for students as they work on and complete this task?

- What resources or tools will students have to use in their work?
- How will the students work -- independently, in small groups, or in pairs -- to explore this task? How long will they work individually or in small groups/pairs? Will students be partnered in a specific way? If so in what way?
- How will students record and report their work?

- How will you introduce students to the activity so as not to reduce the demands of the task? What will you hear that lets you know students understand the task?

Supporting Students' Exploration of the Task

- As students are working independently or in small groups:
  - What questions will you ask to focus their thinking?
  - What will you see or hear that lets you know how students are thinking about the mathematical ideas?
  - What questions will you ask to assess students' understanding of key mathematical ideas, problem solving strategies, or the representations?
  - What questions will you ask to advance students' understanding of the mathematical ideas?
  - What questions will you ask to encourage students to share their thinking with others or to assess their understanding of their peer's ideas?

Sharing and Discussing the Task

- Which solution paths do you want to have shared during the class discussion in order to accomplish the goals for the lesson?
    - Which will be shared first, second, etc.? Why?
    - In what ways will the order of the solution paths help students make connections between the strategies and mathematical ideas?
- What will you see or hear that lets you know that students in the class understand the mathematical ideas or problem-solving strategies that are being shared?
- How will you orchestrate the class discussion so that students:
    - make sense of the mathematical ideas being shared?
    - expand on, debate, and question the solutions being shared?
    - make connections between their solution strategy and the one shared?
    - look for patterns and form generalizations?
- What extensions to the task will you pose that will help students look for patterns, make connections or form a generalization?
- Is there anything else you would like to say about your lesson plan?

Appendix J.

Cool Stuff 1 Assignment Sheet

Cool Stuff 1

Plan, Teach, Reflect for Guided Lead Teaching 1

Executive Summary

You will select and design a lesson for students that is "cool." (We will discuss what it might mean for stuff to be cool.) The first part of the assignment involves selecting a mathematical task of high cognitive demand, identifying the lesson objectives, and connecting those objectives with evidence of your students' learning that you will collect. The second part of the assignment builds on the first and involves seeking information from educational literature to inform your analysis of student learning.

The products for this assignment will be:

- The task that you select and implement
- A lesson plan for the task using the revised lesson plan template
- A *Case-Stories* in-class presentation of your lesson plan and the proposed evidence of learning
- Evidence of student learning in the form of written work and/or other classroom artifacts (e.g., video)
- A Plan-Teach-Reflect paper summarizing the lesson and analyzing student learning

Purpose

The purposes of the Cool Stuff assignments are to give you an opportunity to:

(1) develop a better understanding of what makes a good instructional task
(2) practice both selecting resources and creating your own resources for students [For Cool Stuff 1 you should focus on selecting (and modifying if necessary) an existing task. For Cool Stuff 2 you should focus on creating a new task or substantially modifying an existing task.]
(3) develop skills for connecting your lesson's learning objectives to previous outcomes
(4) gain experience using educational research resources in lesson planning
(5) learn about using formative and summative assessment in ongoing instruction
(6) allow you to share quality instructional materials with your colleagues in class.

The assignment has two parts and each one emphasizes the assignments goals in different ways. In the first part, you will focus on the selection of a *task* of *high cognitive demand,* and on connecting the objectives you write with evidence of your students' learning. In the second part, you'll build on what you learned in the first part by creating a new task and seeking out information from educational research literature to inform the analysis of your students' learning.

This assignment is called "Cool Stuff" because the stuff you are to select or design should be, in your opinion, cool. It is likely, however, that we have differing ideas about what exactly makes stuff cool. By the end of this assignment, though, we should be able to be much clearer about what we mean when we say something is cool to us. That way, we can be clearer about what kinds of activities we would like to make part of our classes, and why we believe these kinds of activities are good.

Procedure

(1) Select a task.
Many cool tasks are already in existence and are readily accessible on the Internet, as well as in volumes of published materials – perhaps in your very own textbook. A number of materials available in our math ed classroom (e.g., textbooks, the *Navigations* series) may be useful. For Cool Stuff 1, you will select an existing task to focus on. The task you select for Cool Stuff 1 should be one that you plan to use during Guided Lead Teach 1.

(2) Prepare a lesson plan.
Before teaching the lesson you'll develop an accompanying lesson plan for the day you use your task. During one class we will share Cool Stuff Case stories, during which time you will be able to see the tasks your classmates are planning to use and give and receive feedback. In preparing your lesson plan, you should consider what evidence of student learning you will collect. This *tentative* plan will be discussed during the Case Stories.

(3) Teach the lesson and gather documents of student thinking
After you've received comments from your colleagues, revise your task or plan if needed. Use the task in a lesson you teach. Enlist help from your mentor or FI to collect written work, audio, video, photos, and/or field notes that capture what happened during your lesson. The use of video is strongly encouraged for this task, assuming you have the appropriate permissions.

(4) Analyze the results, and reflect on what happened

After teaching the lesson using the task, you'll use all the evidence you collected to try to construct arguments about what your students know, relative to your objectives for the lesson. You'll clarify what you hoped would be cool about the task and analyze whether the task turned out to be cool in the end. You will also note things you think you could have done to make the lesson more successful, in terms of either student learning of the objectives or other aspects of the "coolness" of the task. For this portion of the task, you will use the *Plan, Teach, Reflect* write-up format. You are strongly encouraged to include artifacts of student work, particularly in the form of video clips or reproduced (and blinded) student work.

Requirements

As with any assignment in this course, is any of the requirements seem to interfere with your ability to make use of this assignment in your teaching, please let me know **before it is due** and we will negotiate something mutually acceptable.

For Class 3

You will have work time in class to explore the print and online resources we have available in order to select a task. You may want to bring your own textbook from the class in which you intend to use the task. Course instructors will be available to consult with, along with your peer groups.

For Class 5

Write a plan for your Cool Stuff 1 using the lesson plan template. The focus for Cool Stuff 1 is on developing your ability to use artifacts of students' work to construct arguments about whether students have achieved your objectives. In order to prepare for this, pay very close attention to writing good objectives, and the relationship between your objectives and the assessment artifacts you will collect.

Bring 6 copies of your task and plan to class for the Cool Stuff Case Stories.

On the day you teach the lesson

Collect documentation of your use of the task in class. This could include student work, transcribed audio or videotape of the class, and photos of students working on the task. Your documentation should focus on what students did and thought during the task. A combination of these things might do the best job of conveying both a sense of your students' involvement in the task as well as what your students were thinking during the work on the task (e.g., student work alone probably won't tell a rich story). Involve your mentor of FI in helping you collect this data.

Record your own reflection on the lesson as soon as possible. This might include making note of any last-minute or on-the-fly changes to your plan and the reasons for making them. It might also be helpful to write down anything you saw or heard from students that might not be captured in your data.

After you teach

Write your analysis paper in the *Plan-Teach-Reflect* format. This paper should contain two major themes: your analysis of the extent to which your lesson helped you achieve the objectives you had for your students, and your thoughts on whether or not this task was cool.

In the *Plan* section, you should describe how you selected your task, why the task would be considered both high-level and cool, and how you planned for the lesson to go. This should include information on how you set up the task, how you organized students, what questions you intended to ask and why, and how you intended to bring the lesson to closure and discuss the big ideas.

The *Teach* section should be a concise summary of how the lesson went. This is a great place to include student work artifacts and/or video clips.

The *Reflect* section should first analyze student learning. This should include the extent to which your students met the objectives and refer back to evidence from the *Teach* section. The next part of this section should describe whether you thought this task was cool: Was it cool for your students? Was it cool for you as a teacher? What made it cool?

Use evidence from your documentation to support your claims. Finally, reflect on what you learned from this experience, again using evidence from your documentation.

Assessment

You will be assessed using the rubric on the next pages. One particular aspect of the rubric to which we will be paying particular attention to the use of evidence. You should include actual artifacts of classroom practice – student work, pictures of artifacts on the board or chart paper, a set of video clips – to help make an argument about what students learned and whether or not the activity was "cool."

Your in-class presentation of the case stories will also be assessed as a part of your final grade (related to the *Plan* section of the rubric).

Plan, Teach, Reflect Rubric

<u>Plan</u>

Mathematical Goal **1 Point**

1 pt An appropriate math goal is included

0 pts Math goal is inappropriate or not included

Building on Prior Knowledge **2 Points**

2 pts Prior knowledge that students will have is identified and connected to the mathematical task and the mathematical goal

1 pt Prior knowledge that students will have is identified, but connections to the mathematical task and the mathematical goal are weak or unspecified

0 pts No information about how the task builds on prior knowledge

Materials and Launch **2 Points**

2 pts A thorough description of the launch is included, with details about how students are working and what the teacher will do and/or say to launch the lesson
Materials for the lesson are listed and appropriate to the lesson and task(s)

1 pt Either launch description or materials information are absent, OR the materials are inappropriate for the task, OR the launch description is overly general or vague.

0 pts No information about launch or materials

Task Selection and Setup **2 Points**

2 pts The task is a high-level task and is appropriate for the mathematical goal
Information about how the teacher will set up the task is included
Intended task setup does not reduce the cognitive demands of the task

1 pt The task is a high-level task and is appropriate for the mathematical goal
Information about how the teacher will set up the lesson is included
Intended task setup may the cognitive demands of the task, or the setup information is overly general

0 pts The task is of low cognitive demand

Anticipated Student Thinking/Questions **3 Points**

3 pts **Complete** student solutions or thinking paths are clearly identified and represent a range of approaches to the task, varying by representation or strategy where appropriate
Ideas related to student thinking are fully developed and clear
Solutions include **several** incorrect pathways/note possible student misconceptions

2 pts Student solutions or thinking paths are identified and represent a range of approaches to the task, with some variation by representation or strategy
Ideas related to student thinking are clear but general

Solutions include **some** incorrect pathways/note possible student misconceptions

1 pt Student solutions or thinking paths are very general or unclear OR
Incorrect pathways/note possible student misconceptions are not included OR
Student thinking represents a narrow (or single) range of approaches to the task

0 pts No information about student thinking

Teach

Description of Teaching **5 Points**

5 pts A rich description of the lesson is presented
The description includes detail about how the teacher launched the lesson, how students worked on the task(s) in the lesson, and how the task(s) were shared and discussed with the whole class
The description provides **clear information** and **examples** of the nature of both student and teacher talk, including the questions asked by the teacher and the questions asked by students
The description includes a rich body of evidence, which may include but is not limited to transcription of exchanges, written student work, class artifacts (e.g., board work), or video clips
Student thinking is well-represented, and it is clear what students did or did not accomplish in terms of the mathematical goals of the lesson

4 pts (instructor discretion)

3 pts A description of the lesson is presented
The description includes some information about how the teacher launched the lesson, how students worked on the task(s) in the lesson, and how the task(s) were shared and discussed with the whole class, but one or more of these descriptions may be overly general
Examples of teacher and student talk are provided that include questions asked by the teacher and questions asked by the students
The description includes some evidence, which may include but is not limited to transcription of exchanges, written student work, class artifacts (e.g., board work), or video clips
Some student thinking is evident, and it is clear what at least some students did or did not accomplish in terms of the mathematical goals of the lesson

2 pts (instructor discretion)

1 pt A description of the lesson is presented
The description is overly general and one or more aspects of the lesson is poorly represented or missing completely
The description focuses almost primarily on teacher actions OR on non-mathematical student behavior (classroom management)

The evidence presented in the description is limited or entirely absent
It is not clear how students were thinking about the task or what students did or did not accomplish in terms of the mathematical goals of the lesson.

0 pts No description of the teaching is present.

Reflect

Analysis of Student Learning 5 Points

5 pts Claims are made about what students know and understand mathematically as a result of their engagement in the task; these claims are connected back to the lesson objectives
Specific evidence (work, student talk, video, etc.) is presented to support these claims and is well-suited to the claim
Claims about student learning are not limited to a specific student or small subset

4 pts (instructor discretion)

3 pts Claims are made about what students know and understand mathematically as a result of their engagement in the task; these claims are connected back to the lesson objectives
Some evidence (work, student talk, video, etc.) is presented to support these claims, and is suited to the claim but may be limited or overgeneralized
Claims about student learning are not limited to a specific student or small subset

2 pts (instructor discretion)

1 pt Claims are made about what students know and understand mathematically as a result of their engagement in the task
Claims are not connected back to the lesson objectives **OR**
Evidence is not presented to support the claim **OR**
Claims about student learning are limited to a specific student or small subset

0 pts No information is given related to student learning

Reflecting on Practice 2 Points

2 pts The teacher reflects back on the lesson, making strong links between the Plan and Teach sections and using evidence of student learning
Areas of strength and areas for growth in teaching practice are clearly identified
Reflections make strong connections to issues of student learning

1 pt The teacher reflects back on the lesson, making links between the Plan and Teach sections and using evidence of student learning
Areas of strength and areas for growth in teaching practice are clearly identified
Reflections make connections to issues of student learning

0 pts No information about reflecting on practice

Analysis of Coolness 3 Points

3 pts A description of why the lesson was or was not "cool" is included
The description makes links to at least three of the following: the nature of the task, student work and talk, the teaching of the task/lesson, students' prior knowledge, student attitudes and dispositions, use of technology/manipulatives, classroom management
Arguments are well-supported by evidence

2 pts A description of why the lesson was or was not "cool" is included
The description makes links to two of the following: the nature of the task, student work and talk, the teaching of the task/lesson, students' prior knowledge, student attitudes and dispositions, use of technology/manipulatives, classroom management
Arguments are supported by evidence

1 pt A description of why the lesson was or was not "cool" is included
The description makes links to one of the following: the nature of the task, student work and talk, the teaching of the task/lesson, students' prior knowledge, student attitudes and dispositions, use of technology/manipulatives, classroom management, **OR** the links are general and not well-specified
Arguments are supported by minimal evidence

0 pts No analysis of coolness is present.

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